# AMERICAN MACHINIST

A JOURNAL FOR MACHINISTS, ENGINEERS, FOUNDERS, BOILER MAKERS, PATTERN MAKERS AND BLACKSMITHS.

VOL. 17, NO. 45. WEEKLY. | NEW YORK, THURSDAY, NOVEMBER 8, 1894. | $3.00 per Annum. SINGLE COPIES 6 CENTS.



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## Universal Milling Machine.

We present on this page an illustration of a universal milling machine, which has proven the most popular of the new series which were first shown at Chicago, and which indeed enjoys the unique distinction of being a machine which its makers have found impossible to keep in stock during the recent commercial depression; all the various lots manufactured having been sold before completion until the present time.

This machine—which is known as the "No. 2 universal"—is a little larger and heavier than the "No. 1," retaining its handiness and convenience for tool and other fine work, and yet having more driving power and greater strength, so that it is adapted as well for general machine shop use.

All straight sliding surfaces are scraped to surface plates, and cylindrical bearings are ground to standards.

The spindle has a hole its entire length, and runs in bronze boxes provided with means of compensation for wear. It is ground and lapped. The front end is threaded and has a hole fitted for arbors with taper $\frac{1}{2}$ inch per foot and 1.05 inches diameter at the small end.

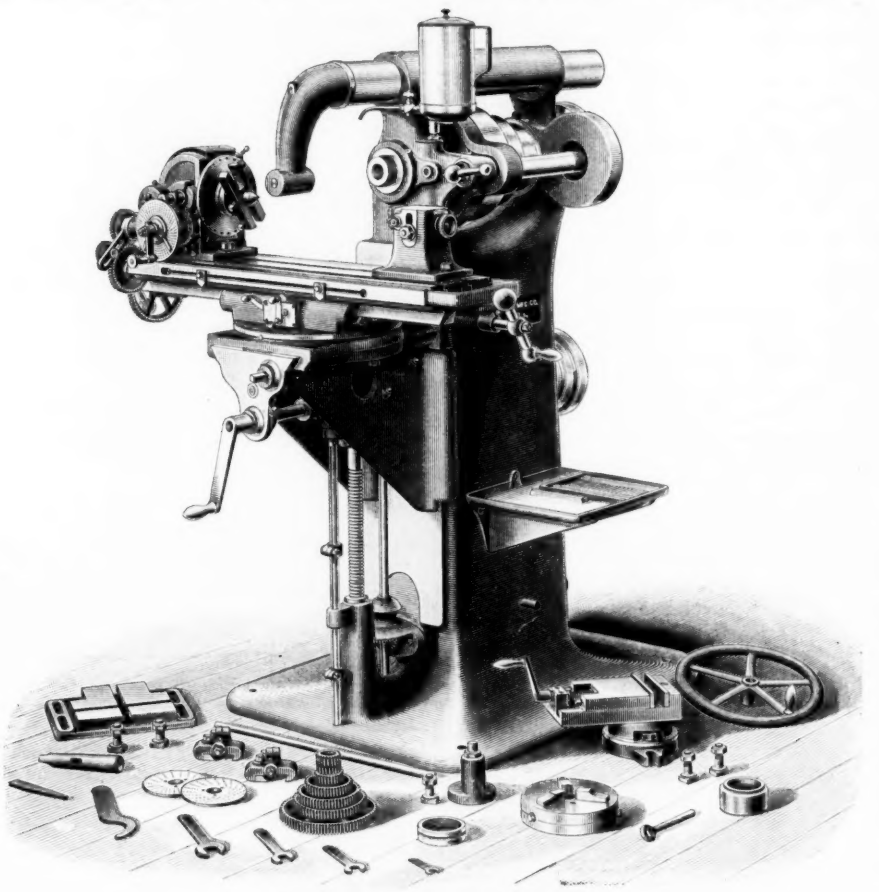
The cone has three steps, the largest 10 inches diameter, for 3-inch belt and is back geared, giving six changes of speed. The gears are covered.

The overhanging arm has an adjustable center, and can be easily reversed to receive an attachment, turned out of the way, or removed. The distance from the center of the spindle to the arm is $5\frac{1}{2}$ inches; greatest distance from end of spindle to center in arm, 14 inches.

The table is $35\frac{1}{2}$ inches long, 8 inches wide over all, and has a working surface 32 inches by $6\frac{3}{4}$ inches. There are two T-slots $\frac{5}{8}$ inch wide. The table has a movement of $6\frac{1}{2}$ inches in line with spindle, and can be moved vertically $17\frac{1}{2}$ inches from the center of the spindle. The feed of table is $20\frac{1}{2}$ inches, and is automatic in either direction. It is reversed by a simple movement of a lever in front of the saddle, and as motion is given the screw at the center of the graduated base upon which the table swings the feed works equally well at any angle, and the table can be set either way up to 45 degrees with the spindle. There are twelve rates of feed varying from .005 inch to .147 inch per revolution of spindle.

The index head is of the new pattern, is very compact, and there is a plate for rapid indexing up to 24 divisions; the worm being thrown out of gear when this is in use. The spindle in this head has a taper hole and is threaded, both to correspond to the main spindle, so that tools and chucks will interchange. Work 10 inches diameter and 15 inches long is taken upon the centers.

The foot-stock spindle may be raised vertically and set at an angle in a vertical plane, thus enabling the centers to be kept in line for all ordinary jobs of taper work. The weight of the machine is about 1,750 pounds and it occupies a floor space 70 inches by 66 inches. It is made by the Brown & Sharpe Mfg. Co., Providence, R. I.

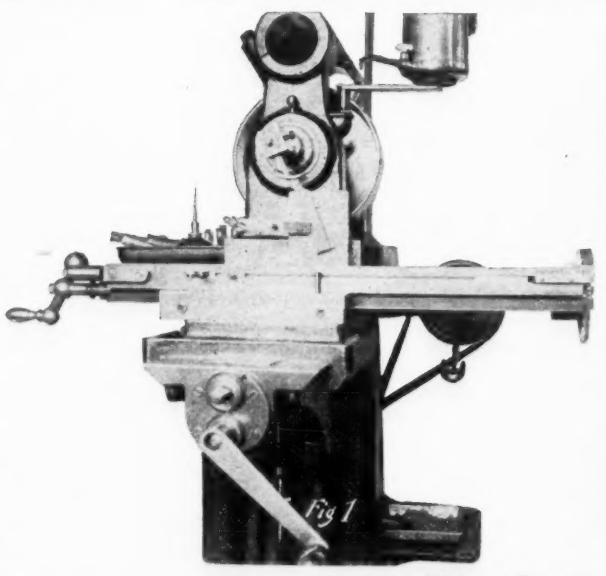


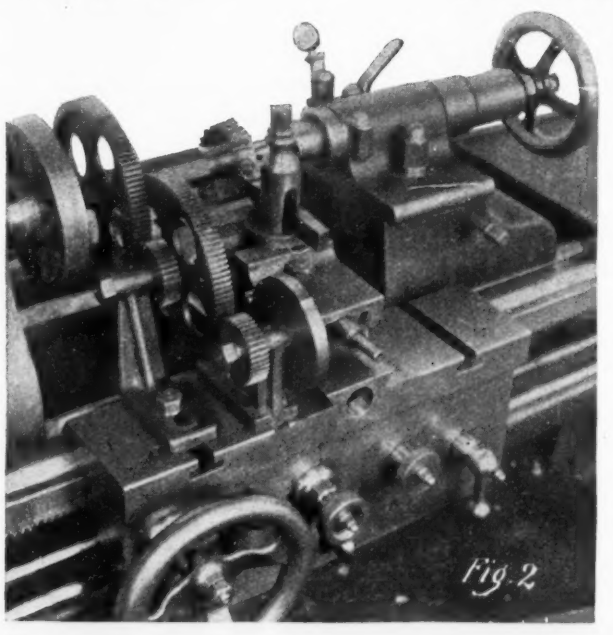
UNIVERSAL MILLING MACHINE.

## Making Formed Milling Cutters.

BY WARREN E. WILLIS.

The use of machine relieved cutters which can be readily ground without special care, and yet maintain their original form, is becoming quite general. They would be used still more extensively were it not for their high cost and the time required to produce them. Notwithstanding this, the makers of guns, sewing machines and kindred work, where duplication of irregular shapes is required, have found their use not only necessary but economical as well. This article is written in hopes it may show a way to overcome some of the difficulties of manufacture in shops having limited conveniences, where their use is not common.




MAKING FORMED MILLING CUTTERS.

The preliminary steps are the production of a template, fly-cutter, lathe tool and cutter blank. The template may be a thin piece of metal, upon which is carefully worked out the desired form of finished cut, either from model or drawing.

The fly tool is a short piece of tool steel, fitted to be held in fly tool holder or shaper tool post, with end extending from holder worked out the reverse of template. The form may or may not be worked across the depth of working face, which face should be at an angle of about 20 degrees from top for clearance.

A piece of glass upon which to place both template and fly tool in fitting one to the other is very convenient, as they are thereby held in the same plane, and this permits the light to show how closely they correspond.

In making a fly tool the whole or part of which is a portion of a true circle, an angular end mill of 40 degrees, included sides, is of assistance.

The cutter blank may be prepared as usual of the desired size, and may be roughed out to something near the finished shape.

A good form of milling cutter for milling the teeth is 12 degrees on one side and 23 degrees on the other, but as the diameter of blank, number and depth of teeth will modify this, no rule will be given. The two angles should be joined by rounded corners, so as to cut out a space sufficient to allow a thin emery wheel to enter in grinding. It is understood that the cutting faces of formed cutters are to be radial.

Make the teeth coarse rather than fine, at least half an inch from one to another, allowing not less than $\frac{5}{16}$ inch length at top, gradually becoming thicker at root of tooth, with space at bottom of about $\frac{1}{8}$ inch.

The lathe tool should be squared up *all over*, and of such size as to be conveniently held in lathe tool post. The end, of course, will be of sufficient width to cover face of cutter desired to operate on. Don't think it a needless expense to make this tool well, as it will produce almost an infinite number of cutters and last indefinitely. To work well it must be held square both in fly-tooling and cutter forming. The straight sides materially assist in this and also in setting at proper angle with the work. Hold the lathe tool either in the vise or clamped against an angle plate at same angle as fly tool, 20 degrees. See Fig. 1. A better way might be to have a special fixture and make all lathe-forming tools of the same size as regards shanks.

The fly tool should be so held that its top and top of lathe tool agree, *i. e.*, lie in the same plane, or else the form produced by the planing action of fly tool on lathe tool will *not* be the same as that of the template.

If used in the milling machine the spindle must be held from turning and the lathe tool moved back and forth by the screw, instead of the fly cutter being revolved to produce the shape.

Having now the cutter blank shaped more

or less closely and milled there comes the consideration of backing off or relieving.

Filing clearance is a job calling for time and care, is usually unsatisfactory on a plain cutter, and utterly impossible when of irregular shape.

An eccentrically centered arbor, with hand lever attachment, is frequently used, involving hard work and irregular length of teeth; and a little reflection will show its entire unfitness for the job. As the cutter

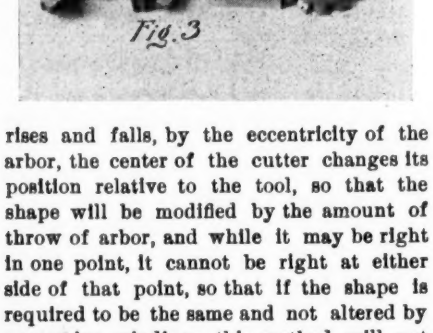


Fig. 3

rises and falls, by the eccentricity of the arbor, the center of the cutter changes its position relative to the tool, so that the shape will be modified by the amount of throw of arbor, and while it may be right in one point, it cannot be right at either side of that point, so that if the shape is required to be the same and not altered by successive grindings, this method will not answer.

The illustration, Fig. 2, shows a simple and correct method of relief which can be very cheaply attached to any lathe having a compound rest; it will take in cutters of any size compatible with swing of lathe, and will answer for any number of teeth.

Worm hobs, taps, etc., can be relieved with equal facility by using a gear of sufficient width, or several narrow ones, placed together so as to allow for movement of the carriage on ways.

A special stiff arbor carrying cutter and driving gear, two brackets fixed to lathe carriage—one for the compound gears, the other for cam and driven gear—and a roll fastened to lower slide comprises the whole outfit.

The gears used are the ordinary change gears of lathe, the proper ones being selected according to the number of teeth in cutter.

The cross-feed screw is removed and a spring or weight used to keep the roll against the former cam.

Feed is secured by the upper slide carrying tool post. The tool being always at same height as centers it has only to advance and retreat, which movement is positively obtained by the proper gears.

Cutters made in this way can be equal to any made, their quality depending, of course, upon the same conditions that govern quality of any other work done in a given shop, *i. e.*, degree of mechanical skill.

## A New Hand-power Drilling Machine.

We present herewith an illustration of a hand power drilling machine, designed especially for use in blacksmith shops and other places where power is not available.

The arrangement of the feeding mechanism is very simple, and by it results are obtained that are of especial value in such a machine. The feed screw is continuous with, and in fact, is cut directly upon the spindle. It passes through a nut which is also a hand-wheel shown in the opening within the frame. This nut, if allowed to do so, revolves with the spindle, and takes the thrust; carrying it upon a ball bearing at the upper end of its hub. When the nut is revolving with the spindle no feed takes place, while, if it is held still the feed is equal to the pitch of the screw, which, of course, is much too fast for most purposes, and the proper rate of feed is obtained by means of a retarding brake which is readily adjusted by a thumb screw, and may be made to retard the wheel (and nut) to give any desired feed. Besides this, it is, in a sense, self-regulating; since, when a hard place is encountered in the work the extra friction of the screw within the nut causes the nut to revolve faster, or more nearly at the speed of the screw, and thus the rate of feed is reduced. It is found that when the friction is adjusted properly for wrought-iron, it will feed slower in steel, faster in cast-iron and very much faster in wood. The feed is found also to be steady and smooth.

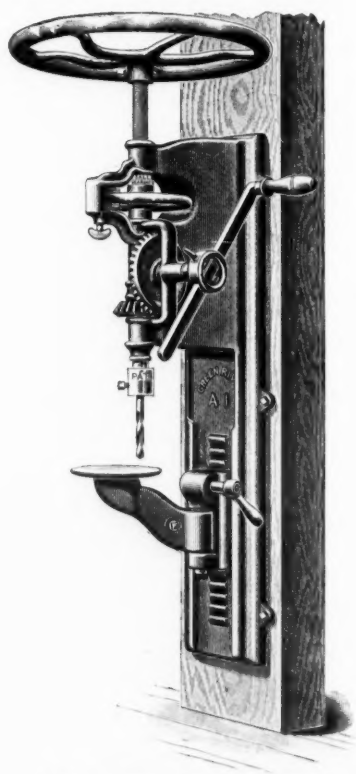
By simply reversing the motion of the crank the drill is run up out of the work, and thus only one hand need be used for driving, feeding and returning the drill The table swings and is adjustable for height. The machine is made by the Wiley & Russell Mfg. Co., Greenfield, Mass.

## Comparison of Different Formulæ for Dimensions of Parts of Steam Engines.—VI.

By William Kent, M E

*Fly Wheels*—The function of a fly wheel is to store up and to restore the periodical fluctuations of energy given to or taken from an engine or machine, and thus to keep approximately constant the velocity of rotation. Rankine calls the quantity $\frac{\triangle E}{2 E_0}$ the coefficient of fluctuation of speed or of unsteadiness, in which $E_0$ is the mean actual energy, and $\triangle E$ the excess of energy received or of work performed, above the mean, during a given interval. The ratio of the periodical excess or deficiency of energy $\triangle E$ to the whole energy exerted in one period or revolution, General Morin found to be from $\frac{1}{8}$ to $\frac{1}{4}$ for single cylinder engines using expansion, the shorter the cut-off the higher the value. For a pair of engines with cranks coupled at 90 degrees the value of the ratio is about one-fourth, and for three engines with cranks at 120 degrees, one-twelfth, of its value for single cylinder engines. For tools working at intervals, such as punching, slotting and plate cutting machines, coining presses, etc., $\triangle E$ is nearly equal to the whole work performed at each operation.

A fly wheel reduces the coefficient $\frac{\triangle E}{2 E_0}$ to a certain fixed amount, being about $\frac{1}{3\,3}$ for ordinary machinery, and $\frac{1}{5\,0}$ or $\frac{1}{6\,0}$ for machinery for fine purposes.


Hand power Drill Press.

If $\frac{1}{m}$ be the intended value of the coefficient of fluctuation of speed, $\triangle E$ the fluctuation of energy, $I$ the moment of inertia of the fly wheel alone, and $a_0$ its mean angular velocity, $I = \frac{m\, g\, \triangle E}{a_0}$. As the rim of a fly wheel is usually heavy in comparison with the arms, $I$ may be taken to equal $W r^2$, in which $W$ = weight of rim in pounds, and $r$ the radius of the wheel; then $W = \frac{m\, g\, \triangle E}{a_0{}^2\, r^2} = \frac{m\, g\, \triangle E}{v^2}$, if $v$ be the velocity of the rim in feet per second. The usual mean radius of the fly wheel in steam engines is from three to five times the length of the crank. The ordinary values of the product $m\, g$, the unit of time being the second, lie between 1,000 and 2,000 feet. (Abridged from Rankine, S. E., p. 62)

Thurston ("Manual of the Steam Engine," Part II., page 417) gives for engines with automatic valve gear, $W = 250{,}000\ \frac{A\ S\ p}{R^2\ D^3}$, in which $A$ = area of piston in square inches, $S$ = stroke in feet, $p$ = mean steam pressure in pounds per square inch, $R$ = revolutions per minute, $D$ = outside diameter of wheel in feet. Thurston also gives for ordinary forms of non-condensing engine with a ratio of expansion between 3 and 5, $W = \frac{a\ A\ S}{R^2\ D^2}$, in which $a$ ranges from 10,000,000 to 15,000,000, averaging 12,000,000. For gas engines in which the charge is fired with every revolution, the American Machinist gives this latter formula, with $a$ doubled, or 24,000,000. Presumably, if the charge is fired every other revolution, $a$ should be again doubled.

Rankine ("Useful Rules and Tables," page 247) gives $W = 475{,}000\ \frac{A\ S\ p}{V\ D^2\ R^2}$, in which $V$ is the variation of speed per cent. of the mean speed. Thurston's first rule above given corresponds with this if we take $V$ at 1.9 per cent.

Hartnell ("Proc. Inst., M. E., 1882," page 427) says: The value of $V$, or the variation permissible in portable engines should not exceed 3 per cent. with an ordinary load, and 4 per cent. when heavily loaded. In fixed engines, for ordinary purposes, $V$ = 2½ to 3 per cent. For good governing or special purposes, such as cotton spinning, the variation should not exceed 1½ to 2 per cent.

F. M. Rites (Trans. A. S. M. E, XIV., 100) develops a new formula for weight of rim, viz., $W = \frac{C. \times I\ H.\ P.}{R^3\ D^2}$, and weight of rim per horse-power $= \frac{C}{R^3\ D^2}$, in which $C$ varies from 10,000,000,000 to 20,000,000,000; also using the latter value of $C$, he obtains $\frac{M\, v^2}{2} = \frac{W}{64\,4}\ \frac{3\,14^2\ D^2\ R^2}{3\,600}$

$= \frac{C \times H\ P.\ (3\,14)^2\ D^2\ R^2}{R^3\ D^2 \times 64\,4 \times 3{,}600} = \frac{850\,000\ H\ P.}{R}$.

Fly wheel energy per H P. $= \frac{850\,000}{R}$.

From these formulæ it appears that the weight of the fly wheel for a given horse-power should vary inversely with the cube of the revolutions and the square of the diameter.

The limit of variation of speed with such a weight of wheel from excess of power per fraction of revolution is less than .0023.

J. B. Stanwood, *Engineering*, June 12, 1891, in an article on "Stationary Engine Practice in America," says: Whenever 480 feet is the lowest piston speed probable for an engine of a certain size, the fly wheel weight for that speed approximates closely to the formula,

$$W = 700{,}000\ \frac{d^3\ s}{D^3\ R^2},$$

$W$ = weight in pounds, $d$ = diameter of cylinder in inches, $s$ = stroke in inches, $D$ = diameter of wheel in feet, $R$ = revolutions per minute, corresponding to 480 feet piston speed.

In a Ready Reference Book, published by Mr. Stanwood, Cincinnati, 1892, he gives the same formula, with coefficients as follows: For slide valve engines, ordinary duty 350,000, same electric lighting 700,000; for automatic high-speed engines 1,000,000; for Corliss engines, ordinary duty 700,000, electric lighting 1,000,000.

Thurston's formula above given

$$W = \frac{a\ A\ S}{R^2\ D^3},$$

with $a$ = 12,000,000, when reduced to terms of $d$ and $s$ in inches becomes,

$$W = 785{,}400\ \frac{d^2\ s}{R^2\ D^3}.$$

If we reduce it to terms of horse-power, we have, $I.\ H.\ P. = \frac{2\,A\,S\,P\,R}{33{,}000}$, in which $P$ = mean effective pressure. Taking this at 40 pounds we obtain $W = 5{,}000{,}000\ 000\ \frac{I.\ H.\ P.}{R^3\ D^2}$, or one-half of the lowest value given by Mr. Rites. If mean effective pressure = 30 pounds, then $W = 6{,}600{,}000{,}000\ \frac{I.\ H\ P.}{R^3\ D^2}$.

For tables and formula for weight of the fly wheel under various conditions, see articles by Emil Theiss, in American Machinist, September 7 and 14, 1893.

*Centrifugal Force in Fly Wheels.*—Let $W$ = weight of rim in pounds.

$R$ = mean radius of rim in feet.

$r$ = revolutions per minute, $g$ = 32.16.

$v$ = velocity of rim in feet per second $= \frac{2\,\pi\,R\,r}{60}$.

Centrifugal force of whole rim $= F = \frac{W\,v^2}{g\,R} = \frac{4\ W\ \pi^2\ R\ r^2}{3{,}600\ g} = .000341\ W\,R\,r^2$.

The resultant, acting at right angles to a diameter, of half of this force acts to disrupt one-half of the wheel from the other half, and is resisted by the section of the rim at each end of the diameter. The resultant of half the radial forces taken at right angles to the diameter is $1 \div \frac{1}{2}\,\pi = \frac{2}{\pi}$ of the sum of these forces, hence the total force $F$ is to be divided by $2 \times 2 \times 1.5708 = 6.2832$ to obtain the tensile strain on the cross-section of the rim, or, total strain on the cross-section $= S = .00005427\ W\,R\,r^2$. The weight $W_1$ of a rim of cast-iron 1 inch square in section is $2\,\pi\,R \times 3.125 = 19.635\ R$ pounds, whence strain per square inch of sectional area of rim $= S_1 = .0010656\ R^2\,r^2$. $= .0002664\ D^2\,r^2 = .0000270\ V^2$, in which $D$ = diameter of wheel in feet, and $V$ is velocity of rim in feet per minute. $S_1 = .0972\ v^2$, if $v$ is taken in feet per second.

For wrought iron, $S_1 = .0011366\ R^2\,r^2 = .0002842\ D^2\,r^2 = .0000288\ V^2$

For steel, $S_1 = .0011593\ R^2\,r^2 = .0002901\ D^2\,r^2 = .0000294\ V^2$.

For wood, $S_1 = .0000888\ R^2\,r^2 = .0000222\ D^2\,r^2 = 00000225\ V^2$.

The specific gravity of the wood being taken at 0.6 = 37.5 pounds per cubic foot, or $\frac{1}{12}$ the weight of cast-iron.

*Example.*—Required the strain per square inch in the rim of a cast-iron wheel 30 feet diameter, 60 revolutions per minute. Answer, $15^2 \times 60^2 \times .0010656 = 863.1$ pounds.

Required the strain per square inch in a cast-iron wheel rim running a mile a minute, $.000027 \times 5{,}280^2 = 752.7$ pounds.

In cast iron fly-wheel rims, on account of their thickness, there is difficulty in securing soundness, and a tensile strength of 10,000 pounds per square inch is as much as can be assumed with safety. Using a factor of safety of 10 gives a maximum allowable strain in the rim of 1,000 pounds per square inch which corresponds to a rim velocity of 6,085 feet per minute.

For any given material, as cast-iron, the strength to resist centrifugal force depends only on the velocity of the rim, and not upon its bulk or weight.

Chas. E. Emery (Cass. Mag., 1892) says: By calculation half the strength of the arms is available to strengthen the rim, or a trifle more if the fly-wheel centers are relatively large. The arms, however, are subject to transverse strains, from belts and from changes of speed, and there is, moreover, no certainty that the arms and rim will be adjusted so as to pull exactly together in resisting disruption, so the plan of considering the rim by itself and making it strong enough to resist disruption by centrifugal force within safe limits, as is assumed in the calculations above, is the safer way.

It does not appear that fly wheels of customary construction should be unsafe at the comparatively low speeds now in common use, if proper materials are used in construction. The cause of rupture of fly wheels that have failed is usually either the "running away" of the engine, such as may be caused by the breaking or slackness of a governor belt, or incorrect design or defective materials of the fly wheel. In the

case of the fly wheel at the Amoskeag Mills, Manchester, N. H., 30 feet diameter, 9 feet face, which burst in October, 1891, the rupture was accounted for by the defects in the castings. Very large blow-holes were found in many of the same, and samples of the material varied in ultimate tensile strength from 15 000 down to 1,000 pounds per square inch

Chas. T. Porter (Trans. A. S. M. E., XIV., 808) states that no case of the bursting of a fly wheel with a solid rim in a high-speed engine is known. He attributes the bursting of wheels built in segments to insufficient strength of the flanges and bolts by which the segments are held together. (See also Thurston, "Manual of the Steam Engine," Part II., page 413, etc.)

*Arms of Fly Wheels and Pulleys*.—Professor Torrey (AMERICAN MACHINIST, July 30, 1891) gives the following formula for arms of elliptical cross section of cast iron wheels:

$W$ = load in pounds acting on one arm; $S$ = strain on belt in pounds per inch of width, taken at 56 for single and 112 for double belts; $v$ = width of belt in inches; $n$ = number of arms; $L$ = length of arm in feet; $b$ = breadth of arm at hub; $d$ = depth of arm at hub, both in inches:

$$W = \frac{S\,v}{n};\quad b = \frac{W\,L}{30\,d^2}.$$

The breadth of the arm is its least dimension = minor axis of the ellipse, and the depth the major axis. This formula is based on a factor of safety of 10.

In using the formula, first assume some depth for the arm, and calculate the required breadth to go with it. If it gives too round an arm, assume the breadth a little greater, and repeat the calculation. A second trial will almost always give a good section.

The size of the arms at the hub having been calculated, they may be somewhat reduced at the rim end. The actual amount cannot be calculated as there are too many unknown quantities. However, the depth and breadth can be reduced about one third at the rim without danger, and this will give a well-shaped arm.

Pulleys are often cast in halves, and bolted together. When this is done the greatest care should be taken to provide sufficient metal in the bolts. This is apt to be the very weakest point in such pulleys. The combined area of the bolts at *each joint* should be about $\frac{98}{100}$ the cross section of the pulley at that point. (Torrey)

Unwin gives $d = 0.6337\sqrt[3]{\frac{B\,D}{n}}$ for single belts.

Unwin gives $d = 0\,798\sqrt[3]{\frac{B\,D}{n}}$ for double belts.

$D$ being the diameter of the pulley, and $B$ the breadth of the rim, both in inches. These formulæ are based on an elliptical section of arm in which $b = 0\,4\,d$, or $d = 2.5\,b$ on a width of belt $= \frac{4}{5}$ the width of the pulley rim, a maximum driving force transmitted by the belt of 56 pounds per inch of width for a single belt and 112 pounds for a double belt, and a safe working stress of cast-iron of 2,250 pounds per square inch.

If in Torrey's formula we make $b = 0\,4\,d$, it reduces to $b = \sqrt[3]{\frac{W\,L}{187\,5}}$; $d = \sqrt[3]{\frac{W\,L}{12}}$.

*Example.*—Given a pulley 10 feet diameter; 8 arms, each 4 feet long; face, 36 inches wide; belt, 30 inches, required the breadth and depth of the arm at the hub. According to Unwin,

$$d = 0.6337\sqrt[3]{\frac{B\,D}{n}} = 0\,633\quad\sqrt[3]{\frac{36\times 120}{8}}$$

$= 5.16$ for single belt, $b = 2\,06$.

$$d = 0\,798\sqrt[3]{\frac{B\,D}{n}} = 0.798\sqrt[3]{\frac{36\times 120}{8}} =$$

6.50 for double belt, $b = 2\,60$.

According to Torrey, if we take the formula $b = \frac{W\,L}{30\,d^2}$, and assume $d = 5$ and 6.5 inches, respectively, for single and double belts, we obtain $b = 1.08$ and 1.33, respectively, or practically only one half of the breadth, according to Unwin, and, since transverse strength is proportional to breadth, an arm only one-half as strong.

Torrey's formula is said to be based on a factor of safety of 10, but this factor can be only apparent and not real, since the assumption that the strain on each area is equal to the strain on the belt divided by the number of arms, is, to say the least, inaccurate. It would be more nearly correct to say that the strain of the belt is divided among half the number of arms. Unwin makes the same assumption in developing his formula, but says it is only in a rough sense true, and that a large factor of safety must be allowed. He therefore takes the low figure of 2 250 pounds per square inch for the safe working strength of cast iron. Unwin says that his equations agree well with practice.

*Diameters of Fly Wheels for Various Speeds.*—If 6,000 feet per minute be the maximum velocity of rim allowable, then $6{,}000 = \pi\,R\,D$, in which $R$ = revolutions per minute, and $D$ = diameter of wheel in feet, whence $D = \frac{6{,}000}{\pi\,R} = \frac{1{,}910}{R}$.

MAXIMUM DIAMETER OF FLY WHEEL ALLOWABLE FOR DIFFERENT NUMBERS OF REVOLUTIONS.

| Revs. per min. | Assuming Max. Speed of 5,000 feet per min. | | Assuming Max. Speed of 6 000 feet per min | |
|---|---|---|---|---|
| | Circum. ft. | Diam. ft. | Circum ft. | Diam. ft. |
| 40 | 125 | 39 8 | 150. | 47.7 |
| 50 | 100. | 31.8 | 120. | 38.2 |
| 60 | 83.3 | 26.5 | 100. | 31.8 |
| 70 | 71.4 | 22 7 | 85 72 | 27.3 |
| 80 | 62.5 | 19 9 | 75. | 23 9 |
| 90 | 55.5 | 17.7 | 66.66 | 21.2 |
| 100 | 50. | 15 9 | 60. | 19 1 |
| 120 | 41 67 | 13 4 | 50. | 15 9 |
| 140 | 35.71 | 11.4 | 42.86 | 13.6 |
| 160 | 31 25 | 9 9 | 37 5 | 11 9 |
| 180 | 27 77 | 8 8 | 33.33 | 10 6 |
| 200 | 25 | 8 0 | 30 | 9 6 |
| 220 | 22.73 | 7 2 | 27.27 | 8.7 |
| 240 | 20 83 | 6 6 | 25. | 8 0 |
| 260 | 19.23 | 6 1 | 23 08 | 7.3 |
| 280 | 17 86 | 5.7 | 21 43 | 6.8 |
| 300 | 16.66 | 5 3 | 20. | 6.4 |
| 350 | 14 29 | 4 5 | 17 14 | 5.5 |
| 400 | 12 5 | 4.0 | 15. | 4 8 |
| 450 | 11.11 | 3.5 | 13 33 | 4.2 |
| 500 | 10. | 3.2 | 12. | 3.8 |

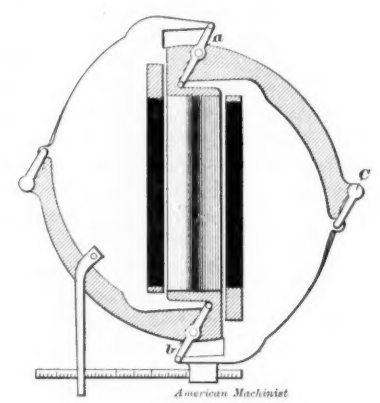


*Fig. 1.*

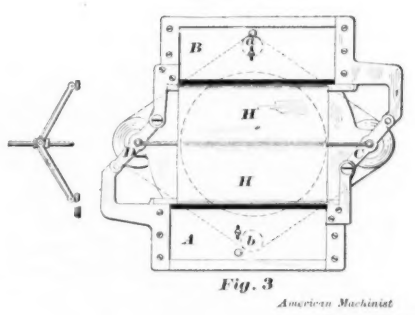


*Fig. 3*

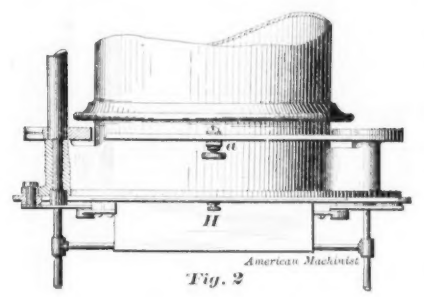


*Fig. 2*

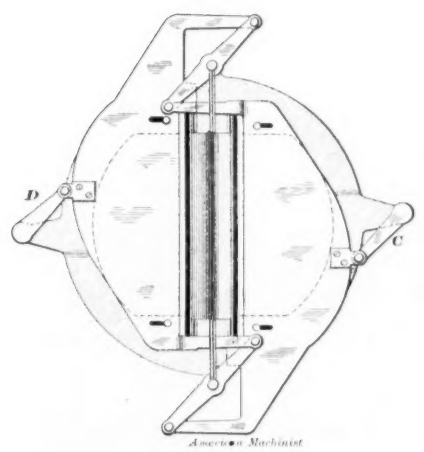


*Fig. 4.*

INVENTIVE PROBLEMS.

## On the Cultivation of the Inventive Capacity by the Solution of Constructive Problems.

BY LEICESTER ALLEN.

I am in receipt of a very interesting letter from Prof. F. L. O. Wadsworth, formerly at Clark University, lately connected with the Astrophysical Observatory at the Smithsonian Institution, Washington, D. C., and now Professor of Physics in the Chicago University. His letter was written from Washington, and calls my attention to a very interesting fact in connection with problem No. 5, which fact I will presently present in his own language.

Before doing so I have to thank Professor Wadsworth also for a very interesting solution to the problem in physics presented to the consideration of the readers of the AMERICAN MACHINIST in its issue of April 26th, which solution is also embodied in the letter referred to. As this solution would be rather out of place among the solutions of problem No. 5, and although this has been formally closed, I will, nevertheless, with permission of the editor, give Professor Wadsworth's letter verbatim, as I feel certain it will interest those who solved the problem in physics referred to, and will certainly be read with great interest by those who solved and who attempted solutions of problem No. 5.

I will place the solution of the problem in physics in a note at the end of the present article: Professor Wadsworth writes:

"My attention has just been called to a problem which you proposed in the AMERICAN MACHINIST of April 26th, and I inclose a solution of it. Before speaking of that, however, I wish to call your attention to the fact that the three crank solution to the previous problem (to which also my attention has only recently been called) is not new.

"The three crank mechanism was used by me for just this purpose in an instrument constructed for the Lick Observatory in 1891, a reference to which is given in the paper, 'Measurement of Jupiter's Satellites by Interference,' by Prof. A. A. Michelson, printed in the publications of the Astronomical Society of the Pacific, a copy of which I send you under separate cover. (See page 276.)

"In Fig. 1 (Fig. 5 in Professor Michelson's paper) $a$ is the driving shaft, $b$ the driven, and $c$ the idle crank which carries $b$ past the dead center.

"A similar arrangement is used on the opposite side of the instrument, not in any way to assist in the motion, but for the purpose of a measurement which need not be described here. This mechanism may be still older, but I have never found any description of it published prior to my use of it in the instrument above cited."

In view of what Professor Wadsworth writes regarding the three crank motion, I can only say in the words of the ancient preacher:

"The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and there is no new thing under the sun.

"Is there anything whereof it may be said, See, this is new? It hath been already of old time which was before us."

I have long ago come to the conclusion that only a very minute fraction of all there is to be known is possible to be grasped by any single mind, and I should not be at all surprised or disturbed to find that each and all of the problems I have given out—or may yet give out—had been studied and solved by one or more previous investigators. It is entirely sufficient for the educational purpose of the problems (their only purpose), that they are new to me, and—as clearly shown by the solutions they have called out—that they are new to a large number of readers of the AMERICAN MACHINIST, and to many constructors of machinery in both hemispheres.

It is gratifying to me, however, that so early in the study of these interesting movements, such evidence of the possible value of some of the movements which have been designed, as Professor Wadsworth has given, is thus afforded.

Professor Wadsworth has kindly called my attention to a paper contributed by him to *Astronomy and Astro-Physics* for August, 1894, which contains a much better description and illustration of the three crank movement than is given in Professor Michelson's paper above named, and as all which he writes upon mechanical subjects is of sterling value (as evidence of which I might cite his admirable paper on "The Manufacture of Very Accurate Straight-Edges" (recently reprinted in the AMERICAN MACHINIST from the *Journal of the Franklin Institute*), I think I cannot at this time do the contributors of solutions to the problems a greater service than to place before them an abstract of what he has to say "On Some New Forms of Double Motion Mechanism," which is the title he has chosen for the paper referred to.

If I cared in the least to dispute the question of priority, I might say that I designed the three crank movement, as described by me in my own solution of the problem, some seven or eight years ago, but as my publication of it in the AMERICAN MACHINIST does not antedate its use in Lick Observatory, nor Professor Michelson's paper, I suppose any claim I might make as to priority would not now be allowed, and I do not desire to press any such claim.

In beginning his paper, Professor Wadsworth says: "I have used the term, 'Double Motion Mechanism,' to designate that form of mechanical movement used in spectroscope slits, astronomical refractometers, and similar pieces of apparatus, for moving two jaws or carriages simultaneously in opposite directions at the same speed. The usual mechanism employed for this purpose consists either of a right and left-hand screw longitudinally fixed and working in nuts on the movable carriages, or a system of link work symmetrical about the central line from which the motion takes place."

The author then proceeds to discuss "the principal points which will govern the choice of mechanism for this particular purpose," which he names as follows:

"1. Accuracy of movement.

"2 Ease and rapidity of movement.

"3. Compactness of mechanism for a given range of movement.

"4. Simplicity and cheapness."

From this point in the paper, as I cannot well condense it, I will quote verbatim.

"As regards the first of these points, the screw system is mechanically superior to any form of link mechanism, because of the number of points at which errors due to imperfect fitting are possible in the latter. Indeed, it is now possible by Rowland's method to make a single screw accurate, so far as uniformity of pitch is concerned, to almost any required degree. The slight difference in pitch between the right and left hand portions of the screw may, if great accuracy is required, be compensated by making the driving nuts independent and separate from the driven jaws or carriages (as in a dividing engine), and suitably inclining or curving the guides along which the tail pieces of these nuts slide. The main cause which tends to inaccuracy in the use of the screw is the necessity for placing it, in most cases, unsymmetrically with respect to the guides for the carriage, in order to avoid obstructing the central part of the field. Then the point of application of the driving force is much nearer one side of the carriages than the other, and there is in consequence a tendency to twist the latter in their ways, which can only be prevented by making the bearing

surface very long, or by using spring gibs, weights, or equivalent mechanical means for bringing the center of resistance to motion into the line of application of the driving force. The first and better method increases the necessary size and bulk of the instrument, and the second is unmechanical, while both considerably increase the friction.

"As regards ease of motion, there is no question of the superiority of a well-designed and a well constructed system of link work, for not only may the driving force be more directly and centrally applied, but the links which move the carriages may also be used to support and guide them, and all sliding friction thereby avoided. The motion too is more perfectly under control than with the screw, and may be made much more rapid without increasing the tendency to vibration or jar. Unfortunately, if any considerable range of motion has to be provided for, the necessary link mechanism becomes bulky and cumbersome, and if compactness is essential the screw is almost a necessity. The last point is, however, of minor importance except in the case of large instruments when it needs to be carefully considered.

"The fourth point is worthy of more consideration than it ordinarily receives. Upon the simplicity of the mechanical design depends, in the first place, its successful operation under the severe conditions of actual usage. It may be taken almost as a general principle that a change of design or construction which cheapens first cost without impairing efficiency, makes the instrument simpler and to that extent more reliable. To explain more clearly what is meant by diminishing cost without impairing efficiency, it may be stated that work which can be done on the lathe is in general cheaper and at the same time more accurate than work finished on the planer or milling machine, and that parts so shaped that they may be made up from standard stock material cost much less than they would if they required special castings to be made for them. Unfortunately, the scientist who designs the instrument is not usually acquainted with the details of the mechanical work and is therefore unable to determine the best and cheapest construction for the whole or for any given part, while the mechanic, on the other hand, while perfectly prepared to answer the latter question when he fully understands the purpose to be achieved, is ofttimes liable to make grave blunders if left to work out details by himself.

"As to relative cheapness and simplicity of these two forms of mechanism much depends on the particular instrument in which it is to be used. In general, the link form will be cheapest and simplest in those instruments not requiring great accuracy, nor involving a large range of movement, and the screw form in instruments where these latter qualities are of primary importance.

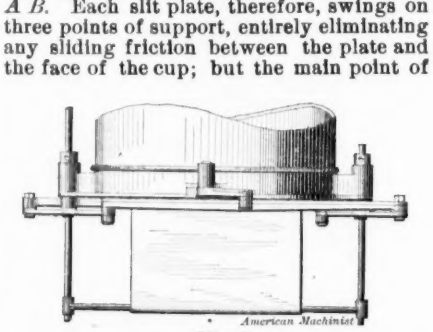
"From what has preceded it is evident that the point of greatest advantage possessed by the link form of mechanism is the ease and smoothness of motion, and that its greatest point of disadvantage is its bulkiness and want of accuracy. The problem with it is to combine compactness with a large range of motion, and accuracy with ease of motion and simplicity. In the case of the screw the main problem is to secure a central driving action on the carriages. To show how these objects have been, to some degree, at any rate, accomplished in particular cases, I will briefly describe some instruments representative of those mentioned at the beginning of the article.

"The first one is that form of astronomical refractometer recently invented by Michelson* which consists of two movable slits placed in front of the objective of an ordinary telescope. In the first instrument of this kind constructed† the slit plates were moved in and out by means of a right and left-hand screw geared to a rod running along the side of the telescope to the observer. Twisting of the slit plates by reason of the unsymmetrical position of the screw was in this case prevented by the use of spring gibs which held the jaws in close contact with the guide nearest the screw. This instrument was, however, unsatisfactory in its operation because of the slowness and stiffness of the motion. To overcome these difficulties in the second instrument a form of link work similar to that used in many spectroscope slits was tried. This instrument is shown in Figs. 2 and 3. The two slit jaws, *A*, *B*, are pivoted to and moved by the double ended cranks, *C*, *D*, which are themselves journaled on the short tube which slides over the end of the telescope. If either one of these cranks are turned the other will of course turn with it, the two slit plates acting as connecting rods, while they themselves receive a lateral motion. In order to make the arrangement as compact as possible the parts are so arranged that the cranks have a motion through nearly 180 degrees, enabling their full throw to be utilized. To carry the driver crank past its dead center it was necessary to gear the two together by means of two steel bands (shown by the dotted lines), which were carried around the cap by means of two adjustable idle pulleys, *a*, *b*, and fastened to two drums on the crank shafts. A folding screen, *H H*, whose function was to keep that part of the objective between the slit plates covered, completes the arrangement, whose methods of operation will be readily understood from the drawings and the description just given. Although far better as regards ease of motion, etc., than the first instrument, it was not entirely satisfactory. Unless the steel bands were quite tight, which caused considerable friction, there was more or less binding and sticking as the cranks passed through the dead center position. Again there was nothing to support the slit plates at the outer sides, except the face of the mounting and there was in consequence considerable friction between them and this face.

"In the third and still larger 12-inch instrument with which the diameters of Jupiter's satellites were measured by Professor Michelson* at Lick Observatory, these last difficulties were completely overcome by mounting each slit plate on three cranks instead of two, as in the previous design. A rough sketch of the instrument is given in the paper referred to below' [this is shown in Fig. 1, herewith reproduced from Professor Michelson's sketch, L. A ]. 'but for the sake of comparison and discussion the more detailed original drawings are here reproduced.' [Figs. 4 and 5 herewith reproduced from Professor Wadsworth's paper.]

"In general, as will be seen by an inspection of the drawings, the design is the same as in the instrument just described. The novelty and great improvement lies in the introduction of two additional cranks or links lettered *D C*, placed about 90 degrees from the two double ended driving cranks *A B*. Each slit plate, therefore, swings on three points of support, entirely eliminating any sliding friction between the plate and the face of the cup; but the main point of advantage which this arrangement possesses is that with it there is no longer a point of dead centers, and hence not only is the smoothness and ease of motion improved, but the accuracy is also increased, as the slit jaws must always remain parallel to each other, and at equal distance from the line joining the centers of rotation of the two double-ended cranks. The only mechanical conditions which it is necessary to fulfill are that the six-crank elements shall be of equal length; but the two elements of the double ended cranks, *A B*, shall lie in the same straight line, and that the axes of rotation shall all be parallel; all of which conditions may be fulfilled to a degree of accuracy at least as great as would be reached, with the same degree of labor, with any form of screw movement. Accuracy, however, is not so important in this case as those qualities which have already been pointed out as characteristic of link mechanism, together with that one not usually possessed by it, viz.: compactness. How far this latter feature has been secured in the present design may be judged from the fact that when closed no part of the mechanism, which has a range of motion equal to the full aperture of the telescope, in this case 12 inches, projects more than 3¼ inches beyond the side of the telescope tube at the objective end; an amount barely sufficient to allow the driving rod, which passes back to the observer at the eye-piece end, to clear the enlarged central portion of the telescope tube.

"It is evident that the use of three crank mechanism, if such it may be termed, is of wide application. The high efficiency of link-work trains, together with their cheapness and durability, renders the use of them extremely desirable in mechanism, and they would, no doubt, be more generally used were it not for the fact that special means are usually required to overcome the dead points. In the case of the two shafts which are to be driven one from the other at a constant velocity ratio (the driving shaft of a locomotive for example), this is done by placing on each shaft two cranks at an angle to each other (usually a right angle), and using two connecting rods. The three crank mechanism accomplishes the desired result in a considerably simpler, more compact and less expensive manner, since it requires only one set of cranks and one connecting rod. Simple and efficient as this device is, I have never seen it described in any book of mechanical movements, nor in any previous publication, and if it has been before used, it does not, at any rate, appear to have been commonly known."



American Machinist

*Fig. 5*

* Application of Interference Methods to Astronomical Instruments. A. A. Michelson, Phil. Mag., July, 1890.

† Ibid, Fig. 1, Plate II.

* Measurement of Jupiter's Satellites by Interference. A. A. Michelson. Publications of the Astronomical Society of the Pacific, 1891, Vol. III., p. 274.

## Inventive Problems.

It will appear that the publication of my own solution of the problem (which was shown to Mr. Miller, now editor of the American Machinist, a considerable time before the problem was printed) was some months prior to the publication of Mr. Wadsworth's description of the movement in *Astronomy and Astro Physics*. I have never seen the Lick Observatory, nor read any detailed description of its instruments. Such descriptions and illustrations of its splendid outfit as I have read and seen have been of so general a character that nothing like a knowledge of any particular mechanical movement, having a peculiar specific object like what has been described by Professor Wadsworth, could by any possibility have been gained from them. Professor Michelson's paper I never saw or heard of before Professor Wadsworth informed me of it. It appears to have been a case of independent invention, and I confess to some pride and pleasure in being found in such eminent company.

Getting this matter straightened out has taken so much space (fully compensated for by the interest of Professor Wadsworth's communication) that only one of the solutions remaining to problems 6 and 7 will be presented in the present article. All of them, however, will be attended to in due course. The little seed planted has proved so prolific, that with other engagements pressing upon me, I am unable to thresh out the entire harvest at once.

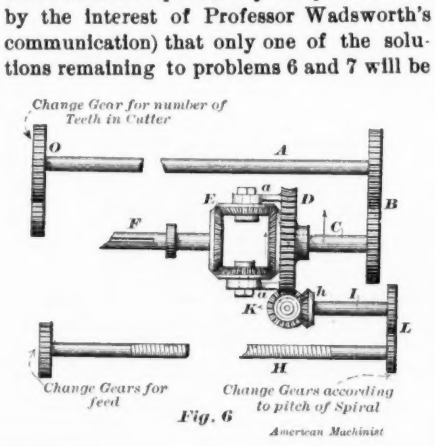



*Fig. 6*

I will conclude this article by presenting one of the solutions of problem No. 6, which have been forwarded to me. This solution has been contributed by Mr. Sturges Whitlock, president of the well-known Whitlock Machine Company, of Birmingham, Conn. Referring to Fig. 6, Mr. Whitlock's description is as follows:

*A* is a shaft at back of lathe driving the splined shaft *F* through gears *B*, shaft *C*, and miter gears *E*. The worm gear *D* of, say, 60 teeth, is loose on shaft *C*, and journals two of the miter gears *E* on lugs *a* projecting from its face.

Worm *K* has its shaft fitted in suitable fixed bearings, the shaft also carrying one of the miter gears *h*, the other miter gear being carried by shaft *I*, which connects through the change wheels *L* with the feed screw *H*. Assuming that there is only one tooth in a spiral cutter, thirty-six inches long, and that the feed screw is .20 pitch, then shafts *A* and *C* will make as many revolutions as the cutter, and the splined shaft *F* the same — 1. The screw *H* will make $36 \times 5 = 180$ revolutions, the worm wheel *D* ½ revolution in the reverse direction of *F*, the worm *K* 30 revolutions, the shaft *I* 30 revolutions, the change gears *L* being arranged in the ratio of 180 to 30.

If there are ten teeth in the cutter, the shaft *A* will be geared through its change gears 10 to 1 of cutter, and so on for any number of teeth in cutter.

This is a very good solution, very tersely and clearly explained. As will be seen, it involves the same general principle of movement—the worm wheel and bevel gearing for transmission, the one modifying the motion of the other—as was employed respectively in the solutions of Messrs. Slocomb and Colburn, printed in issue of September 13th. I had hoped that the consensus of inventive talent which the solution of these problems has shown to exist among readers of the American Machinist would have hit upon some other "way out of the wood," and that something quite new and original in the way of a mechanical movement would have made its appearance, in response to this problem. It is, however, possible that the case admits of no other. The subject will be held open for any new solution that may be forwarded.

Note.—The solution presented by Mr. Wadsworth to the problem in physics printed in issue of April 6th, is here appended. Professor Wadsworth writes:

As regards the other problem referred to at the beginning of the letter, the equation which determines the motion contains an elliptic integral, which can only be integrated by an infinite series. As the mathematical solution is tedious and perhaps too complex for general reading, I will place it by itself at the end of the letter, and state here only the general results, which may be obtained without resource to mathematics, as the problem is one of a compound pendulum.

When the bar falls freely, it will, if we neglect the resistance of the air, fall without rotation, and both ends will reach the table at the same time.

The time of fall will, of course, be simply that required for a body to fall 1 foot under the action of gravity—and will be $\sqrt{\frac{2}{32.2}}$ sec. = very nearly ¼ sec. When only one support is removed, the free end will reach the table more quickly, for the reason that the center of gravity falls a less distance, and although the motion is along the arc of a circle instead of a vertical line, the difference is too small to make up for the difference in vertical descent, the angle of fall being only $\sin.^{-1} \frac{1}{3} = 19° 28' +$.

Further, the fall of the free end through the distance of one foot will be quickest when the support is removed from under the thin end, because the distance the center of gravity falls is then less than in the other cases, or stated in terms of the pendulum, the length of the equivalent simple pendulum is less. . . The approximate times of fall may be determined by determining the time required for a body to fall freely the distance traversed by the center of gravity in each case, the times so determined being slightly less than their true value. The distance from the point of the wedge to the center of gravity is two thirds the whole length, the distance fallen through by it is therefore (since the bar is 3 feet long) $2 \times \Theta = 2 \times .34 = 0\ 68$ foot.

$$\therefore t = \sqrt{\frac{1.36}{32.2}} = 0.20 \text{ sec} +.$$

For the other case (when bar swings down about the thick end) the distance moved by the center of gravity is one-half as great.

$$= .34 \text{ foot.}$$

$$\therefore t = \sqrt{\frac{.68}{32.2}} = 0.145 \text{ sec.}$$

This solution is only approximate because the distance from center of gravity to the point of rotation, and the length of the equivalent simple pendulum, is not quite the same, the error being the greater in the second case.

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The more exact mathematical solution is as follows:

The equation of motion is $\frac{d^2\,\Theta}{d\,t^2} = g\,\frac{h\cos.\,\Theta}{n^2 + k_1{}^2}$, where

$h$ = distance from the axis of rotation to the center of gravity.

$k_1$ = principal radius of gyration.

Integrating we obtain

$$\left(\frac{d\,\theta}{d\,t}\right)^2 = \frac{2\,g\,h\,\sin\,\theta}{h^2 + k_1^2} + \left[c = 0 \begin{matrix}\text{since } \theta = 0\\ \text{for } v = 0\end{matrix}\right].$$

$$\frac{d\,\theta}{\sqrt{\sin.\,\theta}} = \sqrt{\frac{2\,g\,h}{h^2 + k_1^2}}\,d\,t,$$

hence $t = \sqrt{\frac{h^2 + k_1^2}{2\,g\,h}} \int \frac{d\,\theta}{\sqrt{\sin.\,\theta}}$.

To integrate we must develop $\frac{1}{\sqrt{\sin.\,\theta}}$ into a series, as we may do when $\theta$ is small; we have

$$\frac{1}{\sqrt{\sin.\,\theta}} = \frac{1}{\sqrt{\theta}} + \tfrac{1}{2}\,\frac{\theta}{6}^{\frac{3}{2}} + \text{neglecting powers higher than } \theta^3.$$

$$\int \frac{d\,\theta}{\sqrt{\sin.\,\theta}} = 2\,\sqrt{\theta} + \tfrac{1}{12} \times \tfrac{2}{5}\,\theta^{\frac{5}{2}}.$$

$$\therefore\ t = \sqrt{\frac{h^2 + k_1^2}{2\,g\,h}}\left(2\sqrt{\theta} + \tfrac{1}{60}\,\theta^{\frac{5}{2}}\right) + \ldots$$

For $\theta = 19° 28'$

$$2\,\sqrt{\theta} + \tfrac{1}{60}\,\theta^{\frac{5}{2}} = 1.16 +.$$

Also $k_1^2 = 0.502 +$.

For a fall about the thin end

$h = 2$ and $h^2 + k_1^2 = 4.502$.

$\therefore\ t = 0.217$ sec.

For a fall about the thick end

$h = 1.\quad h^2 + k_1^2 = 1.502$

$t = 0.172$ sec.

## LETTERS FROM PRACTICAL MEN.

### A "Mysterious" Leakage of Air.

*Editor American Machinist:*

I have read several articles recently published in the AMERICAN MACHINIST relative to "Mysterious Leaks of Compressed Air," and for the benefit of those who are interested, I will state some facts that have come under my observation in the use of compressed air during the past seven years, during which time I have built about five hundred machines for grinding wood pulp for paper making, on which I use a feeding device worked by hydraulic pressure. It was found that at times the pressure must be relieved, so that the feeding piston could back off from its work to prevent breaking the machine—a movement which the hydraulic apparatus did not permit.

To remedy the difficulty an air chamber, made usually of a piece of 12 inch steam pipe 12 to 15 feet long, closed at both ends, and set in a vertical position, was connected by a 1½ inch pipe from its lower end to the pipe which connected the hydraulic pumps with the machine at a point between the pump and the machine. When the pump was in operation the water was forced into the lower end of the air receiver, and, rising, would compress the air in the upper end, so the compressed air formed a cushion or spring, which equalized the pressure, and afforded relief to the feeding piston as required. The pressure used ranged from 50 to 120 pounds per square inch. Then the trouble began—the air would disappear, and the air receiver be found entirely full of water, with no leaks discoverable, and not a drop of water escaping. The receiver was overhauled, the top cap (screwed on in the usual way) was re-packed by expert steam fitters, and screwed down as tightly as possible by the usual means, the pumps started, and when under full pressure the same tests for leaks were applied as are used to test gas pipes, and the whole pronounced absolutely tight. The machine would run awhile, and the receiver would again be found solid full of water, with no evidence of leakage.

I next stated the case to the manufacturer of the receiver pipes, who had the best of machinery for threading the pipes, and employed him to fit up some of the receivers, but the same results followed, and several very scientific theories were advanced to prove that the air was absorbed by the water.

I then *felt certain* that there was something "mysterious" about the manner of the leakage, and *knew* that the same means of fitting the pipe to hold a like steam pressure would not hold the air. I then set to work to discover the "mysterious" leak, and found that a pipe joint packed in the usual way with red lead packing, would remain tight for several days or weeks, and then begin to leak apparently by the air following the thread of the screw, which probably was not as tight a fit as can be made in small pipes, but by keeping the pipe moderately hot a few hours, the joint remained tight, and the cylinders so treated never failed, while those not heated or "baked" always gave trouble, hence my conclusion, that "with the heat due to steam, the joint would remain tight, but with cold air it would not." I now seal the joints in such air receivers by pouring melted pitch in them, and revolving them so as to coat the entire inside surface, which makes a sure preventive of leakage.

OLIN SCOTT.

### Indicator Connections.

*Editor American Machinist:*

The discussion on long and short indicator connections is growing to be a very interesting one. Up to within a short time the evidence was of a rather fragmentary and unsatisfactory character, and I really hesitate to characterize it otherwise now. It is not of such quantity or quality as would be entertained for a minute in any strictly scientific work, and not until it is, can any conclusions of value be drawn. At all events, however, it is clear that all the conditions of the problem are not thoroughly understood or appreciated. Any engineer of experience, and who keeps notes on his work, as every engineer should, can, I venture to assert, make up a very respectable mass of apparent evidence. He will find places where one thing seems to be true and others when the opposite seems proved. When Mr. Willis' experiments were published I was very much interested in them, but I must confess it was not without surprise that I found them regarded in some quarters as settling the question. So far as I know, they constitute the first attempt to make systematic experiments on the point in question, and, independent of all other considerations, one set of experiments can only be regarded as a small beginning in a long investigation, as this is bound to be from its very nature. This moreover was Mr. Willis' view of the matter. It was in my mind to write something of this tenor at the time the work of Mr. Willis appeared, but when I saw the discussion taken up in so lively a manner I relented, and raked out my note-books.

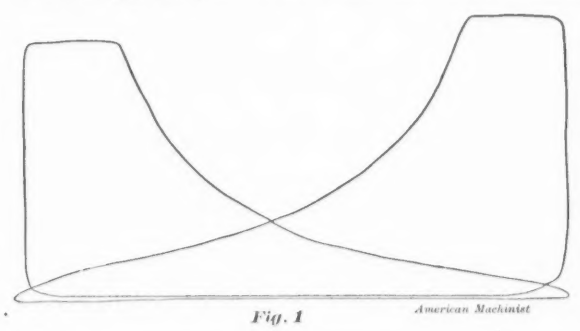



*Fig. 1*

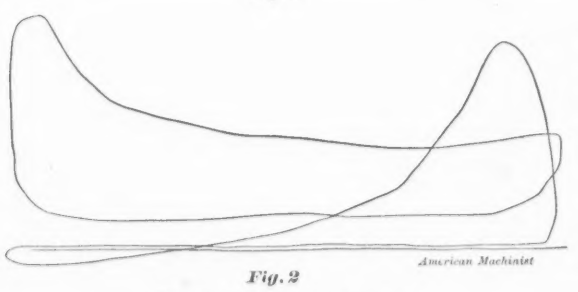



*Fig. 2*

INDICATOR CONNECTIONS.

In the majority of cases it has fallen to my lot to indicate engines in particularly trying localities where either there is nothing to hitch on to, or the cylinder had to be drilled for the cocks, or there were connections already on wrong, or something or other was "off." As a result, I have noted in every case, things which might not be always worth noting. I find that both long and short connections have been used on both long and short stroke, slow and high-speed engines of high and low clearance; and the general tendency would be perhaps a little against the long connections. On the other hand, I have a case on record of a Brown engine, one of a pair 15″x36″, 86 revolutions per minute, where the indicator holes were in the *side* of the cylinder, and the arrangement had been made for upright indicator by means of ordinary pipe elbows and pipe to the center of cylinder where there was a T and an indicator cock; not a three-way cock, oh, no! There was an ordinary globe valve in the pipe just after leaving the elbow at each end. If any one can devise a worse rig I should like to see it, and yet it had to be used, and right off, too. Subsequently the arrangement was entirely changed, proper long connections, *i. e.*, elbows and three-way cock at first, and short connections afterwards. I submit cards taken with the worst and best connections (Fig. 1). I have traced them over each other as well as I could, but it amounts to nothing. The agreement is far within the limits of error. As to this "limits of error" matter, I will say no more just now, for I am intending to deal with that subject in a coming paper. I append to the card given above, another (Fig. 2) showing the condition of the engine when the indicator was first applied.

As to Mr. Willis' results as given, I am not sure I understand how he meant to record them. The engine was said to be a Ball, 10″x12″, making 312 revolutions per minute. This gives a piston speed of 624 feet per minute, and according to a table before me now, the horse-power constant for this diameter of cylinder and piston speed is 1.485. Mr. Willis' horse powers are uniformly smaller than his mean effective pressures, showing that he must have used a smaller factor, about .745 apparently, equivalent to a piston speed of 313 feet or so per minute. Quite likely I am in error, or have not understood Mr. Willis correctly. If, however, the engine was 10″x12″ at 312 revolutions, the horse-powers would be in the first series of tests, for instance, as follows:

| M. E. P. Direct. | I. H. P. Direct. | M. E. P. Indirect. | I. H. P. Indirect. |
|---|---|---|---|
| 27.07 | 40.19 | 27.72 | 41.16 |
| 28.34 | 42.08 | 28.02 | 41.61 |
| 30.17 | 44.80 | 28.91 | 42.93 |
| 31.87 | 47.32 | 31.06 | 46.12 |

The corresponding results here as throughout are identical within the limits of error.

Now, while I believe that in this matter of long or short connections is the traditional gnat at which humanity periodically strains—and that there are numerous camels being swallowed daily in indicator work—still, since we are on the subject, it is a good plan to know what the facts are.

The first question is, Do different experimenters obtain like results working under approximately similar conditions? That is, if five men should indicate each his own high speed engine, would their conclusions be concordant? They ought to be. If this test could be carried out, it would be of considerable value. If the effect of indicator connections depends on simple flow of steam, added clearance and the like, the problem ought not to be a very difficult one. If, however, it is a matter that varies with the engine—if high-speed engines do not all act alike in this particular—we want to know it, and the very first step is to be able to agree on *something*. The only way this desirable result can be reached is by independent and careful experiments, preferably by different experimenters. All the conditions should be carefully studied, and the manipulation of the appliances necessary should be thoroughly mastered. In short, the work must be done on the same scale of care as characterized Mr. Willis' work.

It seems to me, moreover, that it would be very desirable to have the results widely enough published so that they can be read as a whole and weighed, by engineers at large. The whole matter is of special interest. If the results are carefully worked out, they will do much to promote clearer and more just estimations of the accuracy of determinations made with the indicator, a subject on which there seems to be a widespread haziness just at present.

JOSEPH TORREY.

### Formula for Plates.

*Editor American Machinist:*

In a letter published in the AMERICAN MACHINIST of October 18th, Mr. Wm. Kent endeavors to prove my method for calculating the dimensions of a circular plate firmly fixed at the edge and uniformly loaded to be erroneous.

Mr. Kent commits an error when he quotes the formula

$$(18) \qquad h_{max.} = 0\,938\,R\sqrt{\frac{p}{f}},$$

as expressing the uniform thickness of the plate. I have plainly stated in my article of July 5th, that *the thickness varies in a direct proportion with the radius from zero at the center* (theoretically) *to a maximum given by equation* (18) *along the fixed edge.* Although I do not want to make a point of it, I wish to call attention to the fact that in such a case the volume of the plate is considerably less than that obtained by other formulæ.

In the first demonstration Mr. Kent introduces in his formula the coefficient $(\sqrt{\tfrac{2}{3}})$, which renders an analysis of his method quite unnecessary. Much trouble could have been avoided by using Grashof's formula for square plates, as given by Unwin ("Elements of Machine Design," Vol. I, page 93), and saying that the thickness of a circular plate uniformly loaded varies between the values obtained for two square plates, one inscribed in, and the other circumscribed to a circle of radius $R$.

The sides of these plates being respectively:

$$s = \sqrt{2\,R^2} = R\,\sqrt{2} = 1.414\,R,$$

and $s_1 = 2\,R$.

Grashof's formula is $f = \frac{1}{4}\,\frac{s^2}{t^2}\,p$,

where $t = h =$ thickness.

For the inscribed plate $h =$

$$\sqrt{\frac{1}{4}\cdot\frac{2\,R^2}{f}\cdot p} = 0.707\,R\sqrt{\frac{p}{f}}.$$

For the circumscribed plate $h_1 =$

$$\sqrt{\frac{1}{4}\cdot\frac{4\,R^2\cdot p}{f}} = R\sqrt{\frac{p}{f}}.$$

The numerical coefficient for a circular plate is between 0.707 and 1. Grashof found it to be 0.816, making his formula:

$$h = 0\,816\,R\sqrt{\frac{p}{f}}.$$

Whenever an attempt has been made to calculate the strength of a circular plate by considering only a diametral or a rectilinear section of it, incorrect results have been obtained, and it has been necessary to *doctor* the formula by means of a convenient coefficient accounting for all the unknown quantities in the problem.

In my method, *at present*, if I do not treat of the perimetral forces engendered along any circumference by the varying bending moment, it is for several good reasons: 1. In the ordinary cases of practice the materials in use are very far from being either isotropic or perfectly elastic. 2. The consideration of these forces necessitates the use of higher mathematics, and my endeavor is to present my method in the simplest way possible, at the beginning, in order to study in the last part of the work the problem of the plate of even thickness, by employing elementary mathematics only. I will then demonstrate that such a plate is no more uniformly strong than is a prismatic beam of uniform section firmly fixed at the ends, and supporting on one side a load $p$ per unit of area.

I may say here that, in a circular plate uniformly loaded, the isodynamic lines are

all concentric circumferences independently of the thickness, and upon this is based my method. Consequently these considerations should deter anyone from using made up formulæ relating to square plates of even thickness to calculate circular plates of uniform strength.

The complete analysis of the problem includes the hypothesis that a plate may be considered as a flat ring with an inner radius of zero, however absurd Mr. Kent deems it to be, and he may convince himself by consulting Todhunter's "History of the Theory of Elasticity." That the problem of the plate of even thickness has been solved in many ways, and, curiously enough, that the results are all uniform, may be verified by consulting G. Lanza's "Applied Mechanics," containing a translation of Grashof's "Theory of Elasticity"; Navier's, St. Venant's, Resal's, Mathieu's and Clebsch's works on molecular physics and elasticity.

And now to show that Grashof's formulæ are quite up to date, I will quote from one of Mr. Kent's authorities on empirical formulæ, viz., Seaton and Rounthwaite's "Pocketbook of Marine Engineering," page 60: "Cast Steel Cylinder Covers—For a flat plate secured round the edge after the manner of a cylinder cover, but yet not quite firmly fixed, the formula may be written

$$t = h = \sqrt{\frac{3}{4}\ R^2\ \frac{p}{f}} = 0.866\ R\sqrt{\frac{p}{f}},$$

where $t$ is the thickness in inches, $R$ the radius of the cylinder, also in inches; $p$ the maximum pressure on cover in pounds per square inch above atmosphere, and $f$ the greatest permissible stress per square inch on the material, etc." It does not appear from this that the theoretical formulæ of Rankine and Grashof are based on incorrect hypothesis, as Mr. Kent claimed them to be.

ALBERT E. GUY.

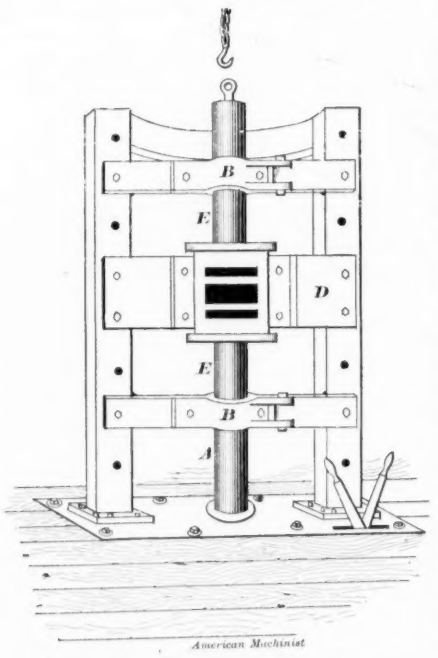
### Making an Original Index Plate.

*Editor American Machinist:*

The article on "Spacing Holes," by "Easy Way," brings to my mind a job of making an index I did some years ago. A steel plate 8″ diameter by $\frac{3}{16}$″ thick was to have eight holes drilled through it equidistant and concentric. The limit of variation was not to exceed the $\frac{1}{250}$ part of an inch. The diameter of the index circle was to be about 7″. All the tools at my command were a 13″ Reed lathe and a small drill press, and the scrap pile usually found in a small shop. As there were to be eight holes in a 7″ circle, their distance center to center is equal to twice the sine of half the angle formed by radii passing through the centers of any two consecutive holes, multiplied by the radius in inches. The angle equals $\frac{360}{8} = 45°$, half the angle $= 22° 30'$, the sine of this angle $= .38268$. Twice the sine $= .76536$. This multiplied by $3.5'' = 2.6788''$ or $2\frac{43}{64}''$ about. Out of the scrap heap I picked some rectangular pieces of cast iron about 1″ by $\frac{5}{16}$″ and about 4″ long. They were all planed to the same thickness, and one edge planed straight. A parallel bar was strapped to the face-plate of the lathe in such a position that by setting the planed edge of the cast iron pieces against the parallel bar and clamping it to the face plate, a hole could be drilled and bored in one end of the piece about midway between its two edges. The eight pieces were successively clamped to the face plate and a $\frac{3}{8}$″ hole bored and reamed into one end, care being taken to get the holes alike. A plug, fitting the holes closely, was fitted to the face-plate at a distance of $2\frac{13}{14}$″ from its center to the center line of the lathe. No great accuracy was required for this, as the chief object was to get the holes the same distance apart in all the links, and in the same position relative to the planed edge. The second hole was bored in each piece exactly the same size as the first. I now had eight links exactly alike. Next, bushings about $\frac{5}{8}$″ long were made, fitting snugly into the links and having a $\frac{1}{4}$″ hole truly concentric with the outside. Eight of these bushings were required. I should have mentioned before that the first holes bored through the links were marked by a center punch mark. A bushing was pushed into the marked hole of one link, the unmarked end of another link pushed over the bushing and another bushing put into its free end. The marked end of the third link was put on the under side of the second link, and so on until completed. A little thought will show the necessity of marking the holes in the way described.

I now had eight links forming an octagon. A chunk of cast iron—having a tit fitting the center hole of the index plate snugly—was turned down and fitted carefully to the inside of the octagon. The whole rig was fastened to the index plate, a bushing to fit a No. 30 drill pushed into one of the connecting bushings or sleeves, as they might be called, and the hole drilled through the plate. The bushing was removed to the next hole and the operation repeated. Finally, a bushing fitting a rose reamer very closely was substituted and the holes reamed, running the reamer very slow and keeping it flooded with oil. A very good job was done this way, a closely fitted gauge fitting any two holes. I believe this success was due as much to my extreme care in making everything as to the method I employed. I have no desire to claim that the method employed is entirely new, although I never heard of it being used either before or since. Neither do I claim that it is adapted to every kind of dividing of the nature described, or that it is the best method possible.

JNO. A. GRENING.




**Shop Tools—Boring Cylinders.**

*Editor American Machinist:*

Ordinary machinists like myself and those who have been trained in ordinary shops, usually have a keen appreciation of the achievements of the higher order of the craft. I refer more particularly to the refinement of machine tools and methods of doing work, all of which tend to elevate alike the standard of machine and machinist. I was very proud of my first steel standard rule, with its graduations of .01 of an inch. Although I could not make a particle of use of these divisions, and, as a matter of fact, I think they are still more ornamental than useful. With standard gauges, however, ground to .0001 of an inch, the machinist may readily set his calipers to .0002 with his eyes shut; so there can be no excuse for not getting things the right size.

I started out to say something about duplicating parts of standard machines, and to notice some of the difficulties met with in practice, which defeat the purposes of the designer.

It is, of course, comparatively easy to construct agricultural machinery so as to make the parts interchangeable, but, notwithstanding this, the user of these machines is often put to great inconvenience by new parts not conforming to old ones. When we come to machinery of a higher order the problem becomes more difficult, and, indeed, many parts may be found that practically defy the best skill to duplicate exactly, or near enough to take the place of a worn or broken part without being worked on. So that, a knowledge of these facts, together with experience, in repairing machinery, leads to the conclusion that much of the interchangeable system, about which a great deal is said, is purely ideal.

This is not saying that the manufacturer would have it so, or that he wilfully deceives his customers Things that contribute to defeat his laudible purpose are numbered by thousands. Besides this, there must be a limit to the cost of such work. It is all right to talk of first drilling a hole, and then running one or two cuts through it with a boring tool, in order to secure certain precision, but all this takes time, and, perhaps, from a business standpoint, the boring must be dispensed with.

Being admonished by these considerations, the foreman cannot say to workmen, "Take your time and do your work well," for this would mean increased cost; but should such work be done by the piece, the remark might be proper enough—a point, by the way, in favor of piecework, at least, as viewed from the standpoint of the employer.

I have found that the cost of work can be reduced some by beginning at the right end of a job. The usual course of a steam engine cylinder through the shop, for example, is first to a lathe or boring machine, and then on the planer. By reversing this order much time may be saved in chucking and more accurate work secured. By planing the cylinder first and providing accurately fitted supports on lathe rest, with fixed stops for adjusting the cylinder, the liability of springing the cylinder, or lathe rest, is greatly reduced, or entirely avoided. The uniformity of the work done in this way is practically perfect, while the processes of gauging and calipering on a planer, after the boring is done, are very uncertain.

Several years ago I constructed a boring machine for boring cylinders in the way mentioned above. It had the merit, to begin with, of taking up very little shop room, a basement however being necessary. Motion for the boring bar was secured by a worm gear; this and the feeding device being out of sight, required no external finish.

Fig. 1 shows the front elevation of this machine. The removable bar $A$ attaches to a permanent bar below by means of a short coarse thread. The end of the bar is conical, which brings it to a central position as it tightens. A number of these bars were provided, each with a fixed boring head, and fixed cutters, thus securing uniformity of bore. The bars were readily removed by opening the swinging boxes $B$ $B'$. A saddle $D$ was fitted for larger cylinders and attachments suited to smaller ones, all of which brought the work to a definite position with relation to the boring bar. A cross feed was used at $E$ $E'$ for facing and turning the cylinder flanges. Material was not spared in constructing this machine, so that all its parts were very rigid, and the work it performed could not be easily excelled either in quality or quantity.

There are advantages gained sometimes by constructing home-made tools, for the designer of these is not required to consider questions that relate to the demands of a general trade, nor is it necessary that a machine should always be self-contained.

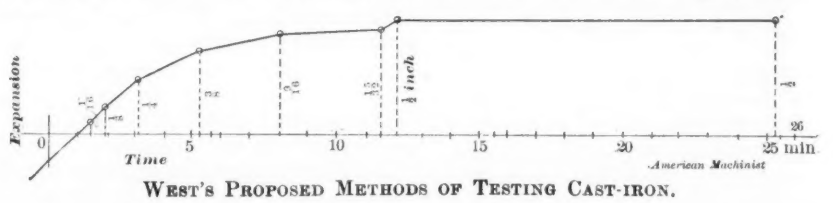
As a general rule, however, I think it best to go to the regular tool builder for machine tools, for most of the attempts of ordinary shops to supply themselves, I have observed, result in complete failure.

"QUIRK."

### West's Proposed Methods of Testing Cast-iron.

*Editor American Machinist:*

In issue of August 30th, Mr. T. D. West describes new methods for testing cast iron, in extension of his suggestions in article of June 6, 1889, and his paper on "Round vs. Square Bars," presented before the Western Foundryman's Association, June 16th, 189[illegible]. As the Committee on Standard Tests and Methods of Testing Materials, A. S. M. E., is now engaged in an extensive series of tests of cast iron, in order to determine the relation between results obtained from test bars of all patterns now in common use and also of cylindrical form, as well as of the methods of tests now in vogue, the writer must defer a complete review of Mr. West's position until the investigations shall have been completed and published. Still, as the subject has been examined to some extent by others heretofore, each one taking up some particular point, a discussion of Mr. West's paper on these lines will not be out of place, especially as his criticism seems to be pointed more directly at the Keep methods, which have thus far given more uniform and reliable results than all others heretofore proposed. It is still a question whether a smaller or larger bar is better suited to obtain uniform and reliable results for all purposes, but a round bar has been condemned by some of the best investigators, and there can be no question but that it has many objections of a practical nature.




WEST'S PROPOSED METHODS OF TESTING CAST-IRON.

Before going into details, I wish to call attention to the fact that Mr. West's recommendations were not based on experience with making and testing round bars, but that his propositions are merely hypothetical. As soon as he shall try to prove these propositions by actual practical work, I feel confident that he will modify them in most essential details. Although square bars are often unsatisfactory (just the same as finished castings), it must be proven beyond doubt that round bars are much superior before it becomes advisable to change to the latter.

Professor Tetmajer, of Zurich, Switzerland, has investigated the preparation of cast-iron test bars, and recommends casting them horizontally instead of vertically, through two gates situated one-third from each end. It was found that when casting vertically from below some irons chill, while in casting from above we have no experience, and it requires the highest skill of the molder, as well as a knowledge of the material, etc. (See report of Munich Conferences, Trans. A. S. M. E., 1889.)

There are so many other difficulties in producing clean, sound, cylindrical (not conical) test bars that methods to overcome these must first be devised and tested by trial before they can be recommended.

The first criticism offered is that contraction cannot be obtained by casting against iron yokes, because of a free expansion of the metal at the moment of solidification. The latter is assumed on the evidence of some tests made by J. R. Whitney and described. Castings have no "moment of solidification," as the metal cools gradually at several points and never all at once, as Mr. West assumes. The method criticised does not allow the test bar to pull away from the chills, for these expand and contract with the bar, and on account of the varying expansion due to changing temperatures. The tests quoted do not prove that iron expands during solidification, but they do show that the brick wall, interposed carbon or brick, and long lever, all expand gradually while being affected by heat imparted by hot metal, and thereby cause the lever to move as explained. Furthermore, the evidence of Prof. Ed. Turner, published in 1835, is valueless, as it is the pressure of the

gradually heated and expanding sand, and not the expansion of the cooling metal, which causes sharp imprint of mold. Castings in the shape of bars, as in Whitney's experiments, become solid in a few minutes. It does not take 25 minutes, but at the end of that time the mold and materials surrounding the cast bar have assumed about the same temperature and have caused the lever to move to its most distant position. Better evidence must be offered to prove that cast-iron expands for a period of 25 minutes after having been cast. By plotting the results of Whitney's second experiment we obtain the curve below, which practically accords with curves of heat conduction, and also shows that the "expansion" (?) of the iron was much more rapid while being chilled, but still liquid, just after casting than at any other time during the period of solidification (?). Thus, while it was still soft and plastic, it is said to have pushed the lever most rapidly. This does appear incongruous. In these tests no account is taken of expansion of any of the abutting pieces under effect of rising temperature caused by liquid metal. Let us now look at his method of making and marking the proposed cylindrical test piece.

In making cylindrical bars, they cannot be cast uniformly without fin at parting line when molded horizontally. This fin is chilled; hence test piece will be defective. However, if molded vertically, the sand cannot be rammed uniformly. Moreover, drawing the pattern (a long one) cannot be done without enlarging the mold, even by expert molders and even when the pattern tapers. Besides, a standard tapering pattern cannot be used for different irons, as then the test pieces would have different dimensions. In any event, uniformly cylindrical specimens cannot be obtained by using a tapered pattern. These are such elementary propositions that proof is quite unnecessary.

The method of marking prints in the sand to be used for measuring contraction is inaccurate; for this must be measured to the one thousandth of an inch, while no such print can be placed positively in its place to the nearest one hundredth; also, to place a gauge over such print and measure the distance between print and end of gauge by a micrometer is an impossible method for accurate work.

The metal all flowing through the lower chill will heat this to such an extent that chilling at lower point is quite indefinite and uncertain. The "fluidity strips" are placed in just such a position as would not allow a natural rising of the metal in the mold at that point, as the current of metal running into the print of test bar will decrease pressure of metal under opening very materially; besides moisture in mold and temperature of sand would also affect the point to which metal would rise.

The proposition to cast a "swell" on the middle of a test bar and then turn it down is very novel and directly contradictory of other propositions which are made for the sole purpose of obtaining a test bar of uniform material. Pouring test bars from one end instead of at the middle, or at two points one-third from each end, is sure to produce bars of non-homogeneous metal; also, the upper end of a bottom-poured bar must have a lesser specific gravity than the bottom end, besides cooling quicker. Accidental displacement of the chills proposed in this method is another possibility, and the bar sliding over the upper chill in cooling, because it can only contract downward, is also a questionable point. In the end chill method the metal remains in contact with the yoke until the bar is absolutely rigid, and only draws away from it upon cooling.

The proposed method of measuring what Mr. West calls "shrinkage," does not at all measure what is designated by that technical term, but merely a phenomenon which will not occur when the iron is fully known and the founder understands his business. This phenomenon can be varied at the will of the founder and depends upon character of metal, temperature of cupola and that at which it is poured. The real shrinkage—longitudinal shrinkage—however, is determined by composition, and temperatures have little effect.

A cylindrical bar cannot be tested with the same degree of certainty as one with flat sides, for the reason that the bearings and pressure block touch the bar in two elements only until the material at those points has been flattened, hence, overstrained (injured), and it would seem *a priori* that the results would be lower than in a rectangular bar of same section and length. Tests have actually shown this to be the case.

From all the above considerations it appears that the proposed methods and shape of test piece would be decidedly unsatisfactory, and substantiation of claims by extensive series of tests must be made before we can accept them as facts.

GUS. C. HENNING.

### Marking Dimensions on Drawings.

*Editor American Machinist:*

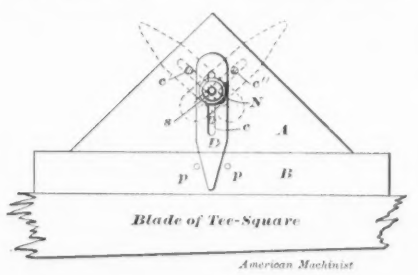
Mr. Oberlin Smith's letter upon drawing details should be learned by heart by every draftsman. Following the same line of thought, I would suggest that it adds greatly to the clearness and practical value of a drawing for the machine shop to write *no* dimensions upon it other than those required by the machinist, but to be sure that every single one of these is put on the drawing. Every size marked on the drawing under this rule means "finished size," and it becomes unnecessary to write anything about the finish except, perhaps, its quality, and, in general, this direction may be left to the foreman. I believe this system is followed by some of the best shops in the East, but it is by no means so general as it should be. A reason for this may be that a draftsman to follow it must do a good deal of careful thinking.

The pattern shop needs these sizes and others in addition, and it is a very easy matter to make the patternmakers' drawing by taking a blue print of the machinists' drawing, and by marking upon it with soda water the additional dimensions and directions which he requires. This will save measuring the drawing by the patternmaker.

I cannot agree with Mr. Smith that the shaded line should be discontinued. To my eye, it adds to the clearness and legibility of the drawing, and there is nothing gained by leaving it out when a separate drawing is furnished to the patternmaker.

The draftsman should bear in mind that every dimension placed on a drawing when it is not needed confuses the machinist, and, consequently, loses time. An *unnecessary* dimension is almost as bad as an omitted one

Newark, N J. HENRY BINSSE




### A Section Liner.

*Editor American Machinist:*

The description of Hill's section liner given by Mr. F. R Honey, in the issue for October 4th, recalls to my mind a device I constructed many years ago, to effect an exactly similar purpose. This was modified from, and was found to be a considerable improvement upon a section liner in use at that time. It consisted of a triangle of hard rubber, *A*, and a parallel strip of the same material, *B*. At about the center of the triangle a stud *s* is fixed, the upper part of which is threaded to receive a knurled nut *N*. The lower part of the stud is plain and slightly larger in diameter than the threaded portion. A slotted tongue-piece *D* of thin metal, which has one end tapered, as shown, is placed on the stud, being secured in position by the nut *N*. A short pin *c* fixed in the triangle, also engages with the slot in the tongue-piece, and serves to keep the center line of the latter at right angles with the lower edge of the triangle. It should be mentioned that both *s* and *c* have slight shoulders at their bases, to just prevent contact between the triangle and the tongue piece.

Two short pins *p p* fixed in the parallel strip *B* complete the arrangement. It will be evident that by suitably adjusting the position of *D*, the space between the lines drawn by the aid of the section liner may be varied from nothing almost to the distance between the pins *p p*. Two other short pins *c'* and *c''* are fixed in the triangle and by unscrewing the nut slightly, the tongue piece could be readily changed to either of the positions shown by the broken lines, thus allowing any edge of the triangle to be employed as desired. When out of use the length of the slot allowed the tongue-piece to be pushed back out of the way, so that no part of it projected beyond the body of the triangle, which could then be used in the ordinary manner. M. E.

### Nominal Horse-Power.

*Editor American Machinist:*

In your number of 4th of this month, we notice an article on "Nominal Horse Power."

In Belgium, we sell a steam engine for the indicated horse power it will develop at a given speed and pressure, and we guarantee that this engine will not consume more than a certain number of kilos of steam per horse-power per hour, working between the full load and two thirds of full load. Besides this guarantee, we also warrant that the number of horse power absorbed by the engine itself shall not exceed a given number. We then give the diameter, stroke, number of revolutions, pressure and cut-off.

To make it clear to your readers, we will give an instance, viz.:

Single-cylinder condensing automatic cut-off engine 113 indicated horse-power.

Diameter 450 millimeters, stroke 900 millimeters, 66 revolutions, cut off one-sixth, pressure 6 atmospheres.

Horse power absorbed by the engine to overcome friction 13 horse-power.

Guaranteed not to consume over 7½ kilos of steam working between 75 horse-power and 113 horse-power.

Concerning boilers, these we sell to vaporize a given quantity of water per kilo of coal. This, on an average, corresponds to 12 kilos of steam per square meter of heating surface.

Now, if we take the above described engine, we have to provide 7½ kilos steam per horse power. That is, for 113 horse-power, 847 kilos; which, divided by 12 is the mean evaporation of one square meter of heating surface, will give us about 70 meters of heating surface, and we will order a boiler of that size.

The boilermaker will guarantee the vaporization between 9 and 14 kilos per square meter, and 10 kilos of steam for one kilo of coal, net; that is to say, water and cinders deducted.

We are under the impression that our method avoids all confusion and enables everybody to know what is meant.

We think that it is worth submitting to your readers, and you are therefore authorized to publish this letter, if you think it good. H. BOLLINCKX.

Brussells, Belgium.

[We should add to this, that the method described is exactly the same in principle as is followed in this country, where steam plants of any considerable size are installed and where engines and boilers are designed and built for given conditions, instead of being *manufactured*, and sold as of some nominal horse power; this latter being the common practice here with most small engines, as we suppose it is in all countries.—ED ]

### Spacing Holes—Making Memoranda—Detailed Specifications.

*Editor American Machinist:*

I have read "Easy Way's" articles on "Spacing Holes" with pleasure, and have no doubt but they will be invaluable to many, whilst the methods given enable the machinist to do close work. I want to tell of a way to locate holes, that, as Frank Richards says about the compressed air for cleaning carpets, has a "git up and git there" to it that rather surprised me.

A little while ago a friend showed me through his uncle's brush factory, and in one place a man was sitting at a small boring machine boring the holes to receive the tufts of bristles; the machine was similar to a lathe head with chuck to hold bits which I noticed were of the old-fashioned kind, known as "duck's bill" bits. The operator sitting, as it were, at the end of the lathe, and the bits pointing away from him. The work to be bored was set in a device, in a sliding carriage, grasped by both hands and brought up to the bit. Suitable stops providing for the depth, the holes were located as follows: A template, the size in length, width, and general contour of the brushes to be made, and about one half inch thick, was bored with the right number of holes; it was laid on the stock, and with a "pounce" of some powder, the operator marked all the holes with about two shakes of the hand. I have known the "pounce" used for perforated paper patterns, but never before for work of this kind.

Let us see how the man who works a punching or drilling machine in a railroad repair shop does it. Templates are provided, made to conform to the different angles and shape, then with a slate pencil he marks around the inside of each hole, then he guesses at the center and marks with center punch. Quite a contrast between the two methods, and I believe the one is about as accurate as the other. An improvement on the driller's plan would be to have holes in templates just the size of a center punch, the shank of which should be parallel. Many cases occur where stops can be fastened to machine, thereby placing work right to receive hole at once, but I believe the workman often resorts to the template business, because it is too much trouble to fix stops, or perhaps, the master mechanic may not have seen the advantage of attaching any convenience for ready adjustment, so there it rests.

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I want to preach to the apprentices what I never practiced very much, and I have two boys that are following in their father's steps in this line. I have reference to the importance to the "cub" of entering in a memorandum book the time it takes for each job he is entrusted with, and also observing how long the "jour," or another apprentice, may be doing a piece of work that perhaps may not be done in the shop very often. If a lad was to carefully do this, it would be far more valuable than anything else when he is called to give an estimate. It would be necessary only to compare the rate of wages paid by different firms, and with the above data at hand, a pretty close estimate may be made of time. The cost of material, shipping, office work, etc, can be gotten at without much trouble.

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Experience is still a pretty good teacher, and although the following may not concern the AMERICAN MACHINIST direct, yet indirectly it may be of use to many.

I was lately called upon to prepare a plan and specifications for a small cottage, and not wishing to incur any more expense than possible, the general drawings were at a scale of ⅛ inch per foot, and details were admitted only to show ornament, thereby leaving much to the honesty of the builder, who "calculated to do a good job if he did not make a cent."

The specifications were generalized something as follows: The framing to have the usual "bracing, bridging and trussing," and that (usual) allows the builder to run all over, and "we never do that" is very often repeated, and should you dare ask if so and so is not going to be done, he sees a nice chance for "extras," because that "wasn't shown," *you know*. Moral—In all and every such case, show all possible details, and specify every thing, even to trapping the sewer, regardless of what we ever or never do. WM. NEWTON.

AMERICAN MACHINIST

Communications relating to the reading columns should be addressed to the Editor. All other communications should be addressed:

AMERICAN MACHINIST,
203 BROADWAY, NEW YORK.

PUBLISHED WEEKLY AT
203 Broadway, New York.

HORACE B. MILLER, Pres't and Bus. Manager.
LYCURGUS B. MOORE, Treas. and Sec'y.

FRED J. MILLER, }
J. G. A. MEYER, } Editors and Mechanical Engineers.

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☞ *We invite correspondence from practical machinists, engineers, inventors, draftsmen, and all those specially interested in the occupations we represent, on subjects pertaining to machinery.*

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$4.00 a year to Other Countries, postage prepaid.

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"Business Specials," 50c. a line.
No Commission allowed to Advertising Agents.

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Publishers' Agents, New York.
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Subscriptions received in Paris, France, by E. TERQUEM, 31 Boulevard Hausmann, at 21 francs per annum, postpaid.

Subscriptions received in Australia by W. WILLIAMS, 17 and 21 Fink's Buildings, Melbourne.

NEW YORK, NOVEMBER 8, 1894.

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## Some Needed International Postal Reforms.

It is to be hoped that it will not be long before some of the many able men who are devoting attention to postal matters, and especially to international postal facilities, will devise a means of introducing something in the nature of a universal international postage stamp, which will carry mail matter, between any two of the chief commercial nations at least, *in either direction.* The need of such a convenience is constantly felt by those who carry on foreign correspondence, or have, or seek to have, business relations in foreign countries, and it would be a very considerable help in carrying on such correspondence.

One of the objectionable features of the present arrangement comes from the fact that it is often necessary to write to some person in a foreign country asking for information under circumstances which make it desirable for the inquirer to inclose return postage, or a self addressed and stamped envelope. This cannot be done, simply because stamps which can be used for sending the reply cannot be obtained by the inquirer.

That the present condition of affairs in this respect is not right is shown by the fact that foreign correspondents of ours frequently inclose stamps for reply—stamps which we can make no use of except to sell them to brokers at about half their face value, and even this resource is not available for most of those who live outside the largest cities.

Another matter which seems to need some reforming is that of international money orders, that is to say, money orders procured in European countries other than Great Britain, and payable in this country. We ourselves are constantly receiving notifications from the post-office in this city that Swedish, or Swiss, or Italian, or German money order No so and so, amount, $4, has been received there, same being payable to us. No name or place is mentioned, and all we know about the matter is that a number of individuals in different parts of the world have written us that they have transmitted the equivalent of $4 to us by post, but which comes from which we know no more than Adam. For the name of the transmitter we are indebted to the courtesy of the New York Post-office people, and to their skill in deciphering difficult foreign names and addresses. Quite as frequently the foreign transmitter takes it for granted, since the original order is not handed to him for transmission, that the post office transmitting the order will also transmit all the information required for our guidance in the transaction. The result is confusion and delay that would seldom or never occur under the duplicate money order system, which is in use in Great Britain and the United States, and which works so smoothly and satisfactorily.

## Hill-climbing Devices for Bicycles.

It is a dull week in these times that does not witness the invention of a new hill-climbing device for bicycles. It is possible that eventually some means may be devised by which the velocity ratio between the pedals and the driving wheel can be changed by the rider to suit circumstances, without introducing objectionable features that more than offset any possible advantage from it, but the difficulties to be overcome in doing this are considerable, and are not perhaps fully appreciated—certainly not by some inventors.

In the first place, and perhaps most important, is the question of added weight. On this point riders and manufacturers are exceedingly sensitive. Any device which is to add, say, a pound weight to the machine, must show such advantages as to make it almost indispensable, or it will not be used. Added complication is also objectionable, but the greatest objection mechanically, perhaps, is the fact that these devices (all, so far as we have noticed) increase the stress upon the driving chain in proportion to the change of speed ratio, and this means increased chain pull upon the rear wheel bearings; every mechanic who has ever investigated the matter knowing that with the excessively small sprocket wheels now commonly used this pull is already excessive in most cases, and is allowable only upon the ground that everything else must be sacrificed to weight, the small sprocket wheels being themselves somewhat lighter, and allowing a somewhat shorter, and consequently lighter chain.

Again, with the present tendency toward "narrow treads," by which is meant the narrowest possible machine, this additional chain pull is objectionable on account of the lack of lateral stiffness in such narrow frames, some of which yield laterally entirely too much even now, allowing the sprocket wheels to be thrown considerably out of line and giving a bad chain action.

Nothing is more certain than that the average rider will make his machine do all he possibly can in the way of hill climbing; and if the maker, by increasing the possible chain pull, enables hills to be climbed not otherwise climbable, he should certainly provide more ample bearings and stronger chains. This would mean another addition to the weight—an addition which would cause most riders to choose another machine.

While we fully recognize the fact that scarcely anything is impossible, yet it seems to us probable that the present practice of extreme simplicity and lightness will continue; and that, all things considered, the best results will be obtained by choosing a gear best adapted to the rider and the conditions under which he rides. He can then walk up hills he cannot comfortably climb, and it will be better both for him and his machine that he should do so.

## Fraudulent "Preparations."

The fact that shop men are, next to farmers, perhaps the heaviest buyers of proprietary nostrums, patent medicines, etc., should make them especially interested in what has been going on in Cincinnati lately, where, a State law giving the Dairy and Food Commission the proper authority, its officers arrested several druggists and others who were fined for selling food preparations and drugs under other than their right names. Amongst the other fraudulent preparations some of the most liberally and most skillfully advertised nostrums figured conspicuously, and the whole proceedings formed a rather sad commentary on the unscrupulousness of some of the human family and the gullibility of others.

There is little doubt but that the American people are more extensively and shamefully imposed upon by this particular form of swindling than any other nation of people upon the face of the earth. They unhesitatingly dose themselves with the first preparation that comes to hand, after diagnosing their cases entirely from cleverly worded circulars or advertisements; and there can be no doubt but that shop men, especially, suffer pecuniarily and in health by the unspeakably foolish habit.

There may be a suspicion that the saying to the effect that he who pleads his own case has a fool for a client, was invented by a lawyer; but there can be no manner of doubt that he who tries to be his own physician, basing his practice upon advertisements, has a fool for a patient, while those who dose helpless children with a preparation of glucose, directly calculated to bring on diabetes, because it is skillfully advertised and sold under another name, or stupefy a child with morphine under the name of a soothing syrup are, in many cases, guilty of that form or degree of manslaughter which results from careless or ignorant killing.

Machinists and other shop men know the result when those who, knowing nothing of such matters, attempt to build or design machinery. Let them remember also that, while it is true that doctors sometimes make mistakes, it is also true that their training and experience give them a vast advantage over mere ignorant experimenting, and that they usually have some other interest in their cases than that of mere money-making.

The most skillfully worded advertising matter may relate to the worst and most injurious nostrum, and the only safe plan is to let them all alone, live in accordance with hygienic rules as nearly as possible, and, when sick, consult a resident physician.

We have received from a correspondent, who evidently knows the funny part of the matter, an account from a daily paper of a locomotive that is to pull a train from Chicago to New York in five hours. There are some wonderful things about this locomotive. It is, of course, to be an electric machine—in a measure—still there is to be steam about it, but no fire or smoke.

This tells its qualities in part, and makes everything as clear as is customary under similar circumstances:

This anomalous machine is divested of all superfluous and disagreeable concomitants. It will have no fire, no smoke, no cinders, no sparks, no tender or stoker. It will have no piston rod, no dead center, no crank, no cylinder, no cam rods or cut-off. Thus minimizing friction.

Then again, and this seems to settle the whole matter:

It is rotary in motion, its motor is steam, but its steam is to be created in transitu by electricity. For which purpose dynamos of requisite capacity will be stored in the upper part of the rear end of the locomotive. In the upper part of the front end will be carried a condenser.

This will reduce the steam to water again, and return it to the tank underneath, to be returned to the boilers by a pump, operated by a wind wheel carried in front of the engine. This arrangement obviates the necessity of delay *en route* to replenish the boiler. Thus, if found desirable, it can, without stop, run continuously as long and as far as there are rails for it to run on.

Our correspondent, W. H. Booth, called attention last week to a feature of English patent law which we are confident is not generally understood here, and he is undoubtedly right in his assumption that the general practice of American patentees is to duplicate in the English patent the claims allowed in the American one. As he points out, the practice is a risky one, for the simple reason that a single vulnerable point in patent claims invalidates the whole patent, so far as England is concerned. In other words, the courts there do not "narrow" a patent or "define its scope" in the sense in which those terms are employed here. They either sustain the entire patent or annul it.

It is probable that ninety-nine out of a hundred patents taken out in England and other foreign countries by Americans are worthless, or at least never pay their cost, and some of our leading manufacturing firms who formerly had all their American patents duplicated in England, have abandoned the practice, simply because "there was nothing in it."

## American Railway Master Mechanics' Association Meeting.

The Joint Committee of the Master Car Builders' Association and the Master Mechanics' Association have decided on Thousand Islands, Alexandria Bay, N. Y., as the place for the next convention in June, 1895. The committee have made special arrangements with Mr. J. B. Wistar, proprietor of the "Thousand Island House," Thousand Islands, Alexandria Bay, N. Y., and Mr. Charles W. Crossmon, proprietor of "The Crossmon House," Thousand Islands, Alexandria Bay, N. Y., as to hotel accommodations. Full information can be obtained by addressing Angus Sinclair, Secretary, 256 Broadway, New York.

## Literary Notes.

We have received from O. J. Edwards, 411 Heed Building, Philadelphia, Pa., a pamphlet containing tables of diameters, areas, weights, etc., of cold drawn seamless steel tubing. The tables were originally

prepared by Mr. Edwards in connection with his work, and are now published at 50 cents a copy.

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The *Textile World*, of Boston, is publishing a complete directory of all the textile mills, bleacheries, dyeing and finishing establishments in the United States, with maps showing the location of mill towns. The maps are divided into five and ten-mile squares, and the location designated by number and letter. October issue gives New England in full, and later issues at intervals will give the mills in other sections, thus completing the entire country during a year's subscription.

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GUIDE IN THE CARE OF STEAM BOILERS AND STEAM ENGINES. By Adolf Schanoj.

This book is written in the German language. The different subjects relating to the care of steam boilers and steam engines are treated from a practical standpoint by an experienced engineer. The instructions given in this book, although based on European practice, will be interesting, useful and beneficial to the young German engineer who has, or aims to have charge of steam plants. The book contains 112 pages, including a good index. It is published by A. Hartleben, Wien, Pest and Leipzig. Price not given.

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THE SLIDE RULE. A Practical Manual. By Charles N. Pickworth, Wh. Sc.

This little paper-covered book of 56 pages gives instructions in the manipulation of slide rules of the Mannheim type. In order to enable the student to use these instruments with intelligence, the author explains first, the general theory, stating the fundamental principles which underlie the operations. This course will give the operator confidence in the results, and an ability to extend the use of the instruments in a large range of their varied capabilities for all kinds of computations, particularly those of a technical character. The whole subject is presented in an exceedingly simple manner, and a large number of examples are worked out, exemplifying the utility of the instrument, and enabling the operator to take the fullest advantage of its usefulness. Those who are interested in the slide rule, and who wish to obtain a knowledge of, and acquire facility in its use, cannot do better than procure a copy of this book. It is published by Emmott & Co., Ltd., New Bridge street, and 56 and 57 Fleet street, London, England. Price two shillings. We presume also that it will be imported to order by any dealer in technical books.

## QUESTIONS AND ANSWERS.

*Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.*

(508) J. Z, New York, writes: Please state what books will give me a fair knowledge of electricity. *A.*—Commence with "Magnetism and Electricity," by S. P. Thompson.

(509) H. G. A., Albany, N. Y., writes: Can you give me any information as to who was the first one to apply the water glass and column to a boiler in this or any other country and the date of the same? *A.*—We know of no record that will give this information.

(510) C. M. A., Orange, Mass., asks: What should be the dimensions of a boat to carry 25 persons? Also give size of engine, dimensions of steam ports, diameter and pitch of propeller? *A.*—Length of boat, 35 feet; breadth, 7 feet; depth, 3 feet 9 inches. Diameter of cylinder, 6 inches; stroke, 7 inches. Steam ports, 4 inches long, $\frac{1}{2}$ inch wide. Diameter of propeller, 24 inches; pitch, 42 inches.

(511) B. H., St. Albans, Vt., writes: Kindly recommend a practical book treating on the metallurgy of iron and steel. *A.*—"Metallurgy of Steel," by H. M. Howe, published by the Scientific Publishing Company, 27 Park Place, New York, is a most complete and standard work. It is a scientific as well as a practical work, but it is expensive, we should advise you to examine it before buying.

(512) A. K. P., Chillicothe, Mo., writes: I want to build an engine with cylinder 2 inches diameter and 4 inches stroke. Please give size of steam ports and exhaust port; also size of steam and exhaust pipes. *A.*—Steam ports, $\frac{3}{16}$x1 inch; exhaust port, $\frac{3}{8}$x1 inch; diameter of steam pipe, $\frac{1}{2}$ inch; exhaust pipe, $\frac{5}{8}$ inch diameter. 2. How much travel will the valve require? *A.*—About $\frac{7}{8}$ inch.

(513) R. R., Englewood, N. J., writes: Kindly inform me, if possible, whether there is a firm in England which makes dynamos and windmills for driving the same. It seems to me that I saw something of the kind described in one of your recent issues, but I am unable to find it. *A.*—We have not described anything of this kind. We have not the names of firms in England engaged in this business. It seems to us that you can obtain in this country dynamos and windmills to drive them.

(514) J. P. M, Worcester, Mass., writes: I desire to design a compound engine for a launch 40 feet long, to make a speed of 10 miles per hour, and would like to have references which will enable me to determine the dimensions of hull and proportions of the engine. *A.*—For determining the lines of the hull, see Peake's "Naval Architecture," and for proportions of the engine, see "Manual of Marine Engineering," by A. E. Seaton. These you may obtain from any dealer in scientific works.

(515) G. F., Erie, Pa., writes: We have noticed the reference in your columns to Natural Philosophy, and having always felt a strong desire to dip into that subject, I would ask you to name some books which are up to date treating on this subject, and where they can be obtained. *A.*—"Elementary Treatise on Physics," by E. Atkinson, translated from Ganot's "Elements De Physique," is considered to be a standard work; it is published by W. Wood & Co., Lafayette place, New York. For the use of beginners Ayer's "Elements of Natural Philosophy" is better adapted and cheaper. It is published by Sheldon & Co., 724 Broadway, New York.

(516) C. S. C, Altoona, Pa., writes: Assuming we have a steam pump with a steam cylinder 6 inches diameter, water cylinder, 4 inches diameter, 7 inches stroke, working against a boiler pressure of 150 pounds per square inch; what will be the speed of the pump when working under full boiler pressure? *A.*—That depends on so many circumstances that it is impossible to give a correct answer. The speed will be affected by the length and diameter of feed pipe, the number of bends in the pipe, weight of reciprocating parts, general construction of the pump, cut off, etc. The best way to get the speed under the conditions named is to test the pump.

(517) A. X. S., Chillicothe, Mo., writes: Please inform me of the best method of constructing a small boiler for an engine of about one half horse-power, safety and cheapness being important factors. I would prefer one made entirely of gas pipe. *A.*—For safety and cheapness we prefer a small vertical boiler; inside diameter of furnace 10$\frac{3}{4}$ inches, height 18 inches; outside diameter of shell 19 inches, height 32 inches; flue, 3$\frac{1}{2}$ inches inside diameter. You can get wrought-iron pipe 12 inches outside diameter which you can use for the furnace; in that case the outer diameter of the shell should be 17$\frac{1}{2}$ inches. You can also obtain wrought iron pipe 4 inches outside diameter, which will answer for the flue. With the use of these all that will need to be made is the outer shell, crown sheets, rings for the bottom of the boiler and furnace door, and such attachments as all boilers of other types require. The above dimensions are for a stationary boiler.

(518) H. G., Philadelphia, Pa., writes: I read your reply to my question relating to air compressors with much interest. There is, however, one point which is not quite clear to me yet. Your formula gives the amount of free air delivered at 20 pounds pressure in 40 seconds, as 100.3 cubic feet, or, in one minute, $100.3 \times \frac{3}{2} = 150.45$ cubic feet. The capacity of the intake cylinder, 11 inches diameter, 6 inches stroke, is 0.33 cubic foot. If the compressor is running at 140 revolutions per minute, the total displacement of the plunger would only be $140 \times 0.33 = 46.2$ cubic feet per minute, so that even under the supposition that the cylinder is filled completely at every stroke with air of atmospheric pressure, I fail to see how it is possible to deliver 150 cubic feet. *A.*—In your former question you did not give the difference in temperature of the free air and that in the tank, and we gave a formula to suit these conditions. If the difference in temperature is taken into account, the results will be different.

(519) C. A., New York, writes: I intend to have a cylinder cast for a launch engine. The cylinder is to be 5 inches diameter and 6 inches stroke. Please give the thickness of cylinder walls, depth of piston, packing rings, diameter of piston rod, and length of cylinder. *A.*—Cylinder walls $\frac{7}{16}$ inch thick, this thickness need not be increased around the counterbore as indicated in your sketch. Depth of piston 1$\frac{5}{8}$ inches, two cast iron packing rings, each cut open in one place, depth of ring $\frac{5}{16}$ inch, thickness $\frac{1}{4}$ inch, piston rod $\frac{3}{8}$ inch diameter. Allowing a clearance of $\frac{1}{4}$ inch at each end of cylinder, and assuming that each cylinder head projects $\frac{3}{8}$ inch into the bore of the cylinder, the length of the cylinder will be $6 + 1\frac{5}{8} + \frac{1}{4} + \frac{3}{8} = 9$ inches. 2. Where can I have the cylinder cast and bored, and what will be the cost? *A.*—You can have it cast and bored in any one of the numerous foundries and machine shops in the city or vicinity. Giving estimates of cost of machinery or its parts is out of our line.

(520) R. L., Leicester, England, writes: I have a number of short lengths of steel wire of No. 50 to 60 Stubs gauge to harden and temper. I have tried the sand bath, but it does not temper them sufficiently even from end to end. Can you suggest a better and safer way? *A.*—We are not quite certain what size the wires are that you are tempering, but we infer that they are quite small in diameter. We think it must be that you are not using the sand bath properly, as our experience is that if used carefully and in the proper manner, it will give uniform results in such work as this. The ladle or vessel in which the sand and work are placed should be the proper form, and should be kept in constant motion during the heating. Heat should be imparted to it carefully, and pains should be taken not to heat the sand at any time much, if any, above the heat required for the color desired. If this is done, we think there will be little if any trouble from lack of uniformity.

(521) J. C, Paterson, N. J., writes: Please give a solution of the following problem: A bar of uniform cross section is carried by three men; one man supports the bar at one of its ends, and the other two men support the bar by means of a rod placed perpendicular to the bar. At what distance must the rod be placed so as to put an equal load on each man? *A.*—The center of gravity is in the middle of the bar. We may assume that the whole weight of the bar is concentrated at its center of gravity. Let $W$ = weight of the bar; according to the condition of the problem each man must support $\frac{1}{3} W$. Taking the origin of moments at the center of gravity, the man at the end acts with a leverage of 15 feet, consequently the moment of the force which this man exerts is $\frac{1}{3} W \times 15$. For equilibrium the moment of the forces exerted by the other two men must equal the moment as found above. Now, let $x$ be the distance from the center of gravity to the rod to which the forces are applied; we then have:

$$\frac{1}{3} W \times 15 = \frac{2}{3} W \times x,$$

eliminating the fractions we have:

$$1 W \times 15 = 2 W \times x,$$

from which we get:

$$\frac{1 W \times 15}{2 W} = x,$$

hence $x = 7\frac{1}{2}$ feet; or the distance from the end of the bar to the rod is $7\frac{1}{2} + 15 = 22\frac{1}{2}$ feet.

(522) T. C. D, Fall River, Mass., writes: I have a shaft on which there are two bearings about 3 feet 6 inches apart with a 48-inch pulley, 24-inch face, between them, over which a horizontal belt is run. One bearing is 14 inches long, and the other one on the end of the shaft is 11$\frac{1}{2}$ inches long. The short bearing is always heating. I have taken the boxes out, and found a good bearing along the box sideways, not at the bottom. I think the end bearing is too close to the pulley and getting all the pull of the belt. The shaft and boxes are in line. What is the cause and remedy? *A.*—If the end bearing is much closer to the pulley than the inner bearing, the former will have a greater pull upon it than the other, but it will not have to resist all the pull, as you seem to think. The pressure upon it, may, however, be sufficient to heat it. In this case the end bearing should be made longer, or the inner bearing moved closer to the pulley. The cause of the heating may also be due to having the belt stretched too tight upon the pulleys, the remedy in this case is evident. The heating may also be due to the use of an impure lubricant; use the best quality of lard oil, or sperm oil, if necessary. On the whole we are inclined to believe that the bearings are too short. If these are made longer and the best kind of lard oil used, the heating will cease. 2. What is the best preparation for cooling hot bearings? *A.*—Use sulphur and oil on the journal and apply cold water—very cautiously—externally.


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### A Chapter in Machine Shop Experience.

*Mr. Editor:*

I never told you anything about that experience Daybroke and I had at Westerly. It was so long ago that it comes up to me as a reminiscence, as the writers say. To tell the truth, I have never said very much about the affair, because it wasn't a howling success, as success is mostly looked at. In fact, that little experience broke Daybroke, and the only reason it didn't break me was because I didn't have anything to break.

As I have intimated, there wasn't anything of success connected with the whole matter, except the success of failure. But do you know, Mr. Editor, there is always something of success in failure? Knowing how not to do a thing is sometimes pretty nearly equivalent to knowing how to do it. When you have found out by experience what will not work, you have got one stumbling-block out of the way, if you have got common sense. If you get fooled twice in the same way, it is rather evident that you never had a call to work in the line in which you are working.

But I started out to tell of the enterprise of Daybroke and myself. You see, it was this way:

Daybroke and I had worked together, at one time, at the Pocannet shops. The Pocannet shops did general machine work, and they made a good many of the plainest kind of plain steam engines. The company made good money in a sort of humdrum fashion. The assets kept creeping up, slow but sure. This suited the older men connected with the works, but younger blood came to the front. Then, Rudell came along with a scheme to out-Corliss Mr. Corliss in the way of a steam engine, with lots of points to spare. Where the Corliss valve gear had one motion, this new engine had four. There was the unlatching motion

another one to see that the unlatching was properly accomplished, another one to regulate the time, and a complicated arrangement, the function of which was to see—so to speak—that the other motions did their duty.

Rudell explained the whole thing to me one day; I could never quite see through it. But the engine, just as he had put it on paper, looked mighty nice. If you couldn't see why or how it would work, you couldn't see why it wouldn't work, and what more could you ask?

Daybroke and I somehow got most of the work on the first—and the last as to that—of Rudell's engine. Daybroke had worked in the big Eastern manufacturing establishments, and knew all the advantages of having everything right. The assumption was that there were to be about a million—more or less—of these engines built, so he made jigs and templates for every piece of the valve motion, and made all the parts by system. To be sure, the company never built but this one Rudell engine, but they might have built thousands from Daybroke's jigs and templates, so far as the valve motion was concerned.

Daybroke, having worked in the big manufacturing establishments, did the fine work of the valve motion mechanism, while I, who had knocked around only in a general sort of a way, did the rougher work. I knew how to turn the shaft, fit the crank on, get the pin in line, and set the engine together reasonably true.

Between us we got the engine completed, and it was sold to the Westerly Manufacturing Co. After considerable persuasive effort it settled down to running, and did pretty well for nearly a year. Then some of the joggers began to fail to jog, and the whole valve motion went astray. As there wasn't another mechanic in the United States who had mastered the intricacies of that valve motion, there was nothing to do but send for Daybroke. He had jigged it all out, and studied the author's drawings by the hour. He, if any one, knew its infirmities. He knew that there were certain things that had to make certain other things work, and he could rebuild the whole business, if necessary. But it wasn't so bad as that.

Daybroke went to Westerly to doctor that valve gear.

Westerly is only about thirty miles from Backaway. It is a pretty considerable town—what they would call in some of the Eastern States the Shire town. The courthouse is there, and affairs in law and equity are attended to generally. But this wasn't, so far as Daybroke and I were concerned, the most important thing at Westerly. The particular thing that wrecked us was Old Man Waller's machine shop. Waller had started this shop so far back that no one could fix the date, and he had forgotten it himself. He grew up, not exactly with the town, but in the town and with the surroundings. Little mills and little factories had come into existence all around Westerly, and for a radius of about fifteen miles they were tributary to Waller. He had the patterns from which their gears and pulleys were made, and had furnished them with shafting, mill spindles, cock bills, spindle points and the like, for years almost uncounted, Waller had. When his shop got too small, he put a lean-to here, then made a side extension there. It was—as a whole—"without form and void," and reasonably well filled with antiquated tools, for the most part. There was, for example, a lathe that would take in a long shaft, but there were two or three points where the carriage had to be pried over intervals where the feed failed to connect. Waller said he didn't use this lathe more than three or four times a year anyway, that a good man could get out a satisfactory job, and that, after all, it was cheaper for his customers to pay for a little extra time than to pay the interest on the price of a new lathe. If he wanted to use that lathe three hundred days in the year, he admitted it wouldn't be worth shop room.

Anyhow, Waller had worked along with his old tools and old methods and old shop, and he had worked up to a pretty good bank account.

As I have intimated, Waller's shop was the only one in Westerly, so when Daybroke found he must have some machine work done he had to take it to Waller's; had to take it there and do it mostly himself. Being around the shop for a week he couldn't help hear when this man came in with blood in his eye because that last gear was bored too small, and another indulged in profanity because the shaft he ordered was too large. Daybroke did a good deal of thinking about these things. He was always a powerful thinker, was Daybroke. What bothered him was that all the profanity, implied and expressed, didn't seem to bother Waller.

One day when Daybroke was putting the finishing touches on the second motion Grab-in claw Waller came along, watched him for a few minutes and said:

"Daybroke, why don't you go into business for yourself?"

Daybroke allowed that he had often thought of doing so, but had never seen just the right chance.

"Now, Daybroke," said Waller, "I'll tell you what I'll do; I'll sell out to you. I've worked along here so long that I should have to do some figuring to count up the years. I've made a little money now and then—enough to keep me I reckon—and I'm getting a little tired of gears and pulleys and shafts. I just want to go fishing. I rather like your ways, and I'll sell out to you so cheap that you'll be astonished. Think it over," continued Waller.

Daybroke did think it over, and the out come of his thoughts was that when he got that valve motion all put right he came to see me.

At that time I was running a little engine for Jobbins; there wasn't much work in it, and there wasn't much money in it. I didn't mind the scarcity of work, but the financial part troubled me. So when Daybroke opened up the subject to me I was inclined to catch right on; till I happened to think that I didn't have any ready money. That's what I told Daybroke, but he brushed this all away by saying that the unfortunate death of an uncle had left him with about twenty thousand dollars, and this, he said, would start us right smart.

Daybroke was enthusiastic. Said that Waller would sell out for a song, and that would give us an abiding place, so to speak. Give us a sort of ground floor—"a point from which to reach out," as Daybroke put it.

Then Daybroke said we would revolutionize machine shop practice round about Westerly. When we made a gear with a four-inch hole through the hub that hole would be four inches, and nothing else, and a three-inch shaft would be three inches just as near as it could be come at by the best standard gauge in the country.

"Why," continued Daybroke, "we will fix all the things mechanical in the whole county; fix them so that Jones' gear will fit Smith's shaft, key-seat and all, as if it were made specially for it."

I had a little lingering doubt as to the possibility of doing this, a sort of foolish doubt, as I then thought, born of some experience in this kind of work where I had to figure on the personal equations of a good many millwrights; had to figure on these with the certainty that Allison was a little slack in his measurements, while Tompkins was always a little over size; but Daybroke's enthusiasm conquered.

You see, Mr. Editor, if you only put the flag to the front and order the band to play the national air the soldiers will march to death just as readily as they will fall in for rations or dress parade.

Well, to make it short, Daybroke and I bought out Old Man Waller. I want to put it on record that Waller was mighty fair in the transaction. Didn't stick for much of a price, and offered to take our note for half the purchase money.

We bought out Waller and Daybroke took right hold as mechanical head of Daybroke & Oldone, Engineers and Machinists. The title sounded good, and everything looked fair.

It didn't take much of Daybroke's capital to satisfy Waller, so he put matters in my hands, temporarily, and started East to buy tools—grinding machines and standard gauges especially. The understanding was that I was to run along quietly till he got back, and that in the interval I was to build a cheap extension to Waller's shop—which consisted chiefly of extensions anyhow—in which to store the old tools, which Daybroke said were not worth anything, but it was too bad to break them up.

Well, Daybroke got the tools, I got the extension built and we moved the old tools and set up the new ones. In the interval I had taken care of the customers who favored us; taken care of them in the old-fashioned way. I knew it wasn't the right way, but it was the best I could do till Daybroke got back. I didn't know much about the patterns, and no one in the shop seemed to know much about them. But Old Man Waller hadn't gone fishing yet, and every day he used to wander into the shop, for all the world like the ghost of departed Preeminence. And he helped me out.

He seemed to know, without an effort at thought, just where everything was.

One day Jobson came in and ordered one gear and four pulleys for the corn cracker department of his mill—was going to change the speed all the way through. All he said was, "to be bored 3½ inches." Waller happened to be standing by, and when Jobson had gone out he said, "Oldone, you bore that gear and those pulleys just about $\frac{1}{64}$ inch large or you will hear a howl from Jobson."

I had them bored $\frac{1}{64}$ inch large and never heard any complaint.

But as I was saying, Daybroke and I got the old tools out and the new ones in, and we made a fine stand for the gauges. It was during the dull times that will always strike such a shop as ours in the summer, and what bother came to us I looked after, while Daybroke established our System. Then Daybroke took hold of the mechanical department—took hold of it in real earnest.

Out in Savery, about 10 miles away, were four little mills that Waller had equipped 20 years before. They all belonged, just then, to one party, who employed a millwright whose name was Emerson. Emerson came into Westerly, and to our shop with two or three orders. One was for a gear wheel. He had measured it and counted the teeth, and knew all about what he wanted. Daybroke got the pattern hunted out, and then he said:

"Mr. Emerson, can't you see that the teeth of that wheel are all wrong? We don't propose to sell gears with such teeth. We will make a new pattern, you paying for it, that will be correct in principle, which, with a new pinion pattern we shall have to make, will give that peculiar rolling motion that good gearing ought to possess."

Emerson flared up. "Twenty years ago," said he, "I passed upon that gear pattern as being about right, and now you propose to prove me a fool. That gear," he continued, "has gone right along doing its work for 20 years, and if you don't want to make me another one from the same pattern, I'll get a new pattern made somewhere else."

In the end Daybroke gave away and made the gear.

The next day Burger came in and he wanted two pulleys—24 inches and 36 inches—and he wanted them bored 3⅞ inches, "a little proud."

"We don't know," said Daybroke, "anything about such expressions. We can make those pulleys, and the bore will be just exactly 2⅞ inches, but when you talk about 'a little proud,' we don't understand what you mean."

I happened to be standing by, and I nudged Daybroke as an intimation to let up, but it was no use, he had his war paint on, as the story books say.

You see, it wasn't owing to any superior knowledge I had, but I had had to do with millwrights enough to know that "a little proud" meant just under $\frac{1}{64}$ inch large. I couldn't express it in common fractions, or in decimal equivalents, but, Mr. Editor, you have rattled around machine shops enough to know that there is a sort of undefined language that doesn't get anywhere near the thousandths mark, but still means a good deal to the machinist who is a mechanic as well. It's a sort of freemasonry among mechanics that no fellow in the world can explain. If you were right back in the shop, apron on and ready for business, and you got an order to bore some constituent part of a machine "a little proud" or "a little slack," you would get right there within all reasonable requirements. I don't mean to say that you would get down to the point that you would if you could get your inside and outside calipers together, but you would get there in a way that would answer the purposes of ordinary machinery.

But this doesn't matter much. It went from one thing to another. Jenkins wanted a 30 inch gear bored the same size as his last one ordered. There was no record of what particular size the last one was bored.

Smithers sent in an order—wanted at once—a shaft, length given to transmit 50 horse-power. Daybroke wrote to Smithers asking him how fast his shaft was to run, and what the conditions of its running were.

Well, he got back word that he was inventing a machine and didn't propose to tell anyone how fast it was to run, and that a man who advertised himself as an engineer ought to know how much power a shaft would transmit.

But what finally broke Daybroke all up, and this was after we had lost money steadily for two years, was when Southern came in with a job to refit five mill spindles. They had to be "laid up" and put in order generally. Southern brought in with him about fifteen little twigs of an apple tree—green cut—and these represented the sizes to which the shafts were to be finished, in their various sections. That broke Daybroke's heart.

"Oldone," says he, "I've lost my money here, and you have lost your time. I'm going to get a five horse-power engine to run somewhere. It is better suited to my capacity than trying to reform standards where no reformation is wanted. I'll tell you," said he, "when you come right down to ordinary machine work, you have got to make things fit, one to the other, and if the size is out according to your way of reckoning, you have got to get your methods down to common practice."

Daybroke didn't stay running that five horse-power engine very long. To day he is at the head of one of the big establishments of the country, while I am just running the big engine at Backaway, and kind of looking after things mechanical, as they come up.

But I haven't told you just exactly how the whole enterprise was concluded. We had a man working for us by the name of Peterby. Peterby was one of the assets of Waller. No one thought Peterby knew anything in particular, but somehow when he had his way on a job it came out right. If you just told him what to do, why he did it just as you said, but if you said, "Peterby, look after this job, and see that it comes out right," there was never any trouble with it. Peterby never had more than one suspender in active operation on his overalls, and he just looked as if what he didn't know would fill an encyclopedia. But you know, Mr. Editor, that you sometimes get an idea, and a pretty correct one, that a man knows more than his clothes make him look like knowing.

So it came around that when the R. I. P. canal was changing all of its locking facilities, the contractor came to us to fix up his mechanical arrangements. He had to put in his power plant here, then he had to run off at an indefinite angle there, and put in his centrifugal pump to get rid of the water, stones, etc., then he had to shift the pump, and so on without end. He said he had lots of shafting, and angle couplings, but Daybroke and I concluded it would take a first-class draftsman about two months

to figure out what he could do. The contractor couldn't stand this, and as we happened to know that Peterby had rattled around amongst such work some, in sheer desperation I appealed to him.

Peterby—he was born at Cape Cod—allowed that if he had his own way in the matter, he could keep the water out of the way. Didn't know much, he said, about such matters, but he reckoned that it was a sort of a question of common sense. There was something to be accomplished, and you had to get there to accomplish it. We detailed Peterby, with full power to help along the canal enterprise. He came out with colors at the front. He ran wire belts around curious corners, and sets shafts at undefinable angles. No one in the world could formulate the manner in which he connected the power at hand with the work to be done, but he got there somehow, and it didn't seem to trouble him any either.

Well, it came about that when Daybroke and I saw we must break up at Westerly, that Peterby got along up to us one day, and asked us if we wanted to sell out. Said he had heard we were tired of the business, and he thought he might make a living at it, if we didn't crowd him too hard on payments. Didn't want to get rich, he said, but would like to grind out a living. He couldn't make a drawing, he said, only on a board with a 2-foot rule, but he knew what the customers around Westerly expected. There were, he said, a lot of millwrights scattered through the country, and when you tried to convince them that they couldn't measure 3 inches on a box wood rule with the marks all worn off, you made a mistake, you had to get the hang of the whole thing; sort of find out; Cranston's 3 inches was always a little over-size, while Milton's was a shade small.

"If you try," said Peterby, "to change the prevailing system of work in a locality like this with a sudden jerk, you are beat as sure as you live. You've got to work up to it cautiously, and it will take a lifetime to do it. That's why so few try it. Life is too short, and men don't want to put in all their efforts for future generations."

We sold out to Peterby, and he has gone right on running that Westerly shop ever since, and he has been making money, too.

Very truly, JOEL OLDONE.

## Measurement of Areas Bounded by Curved Lines.

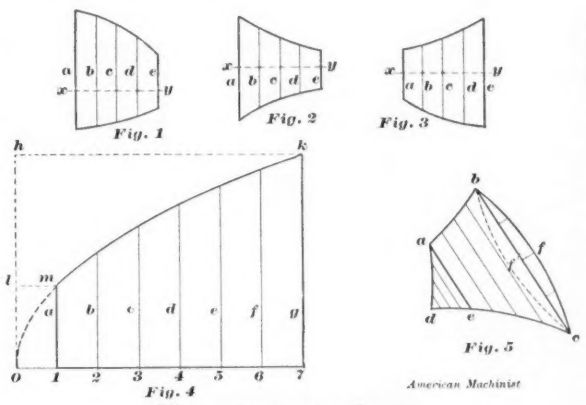
BY PROF. F. R. HONEY.

In my paper on "Hyperbolic Logarithms," I employed Simpson's rule for calculating approximately the area included between the hyperbola and the axis of $X$. The rule is applicable in measuring the area of a figure bounded by *two* curves and two parallel straight lines. The possible combinations of curves are illustrated, *i e*, they may be concave (Fig. 1), or convex (Fig. 2), towards each other, or situated as in Fig. 3. If any line $x\ y$ be drawn at right angles to the ordinates, since Simpson's rule is applicable in finding the area on each side of $x\ y$, it may evidently be applied directly to the *sum* of the ordinates limited by the curves. Thus the area in Figs. 1, 2, or 3 $= \left\{ a + e + 2c + 4(b + d) \right\} \frac{1}{3}$ in which $\frac{1}{3}$ means one-third the common distance between the ordinates.

There is another rule attributed to Simpson in which the number of intervals must be a multiple of three, as for example, six—*m 1 7 k*—Fig. 4 It reads as follows: *Add together the first and last ordinates, twice every third intermediate ordinate, and thrice each remaining ordinate; and multiply by $\frac{3}{8}$ of the common interval.* Thus the area $= \left\{ a + g + 2\,d + 3\,(b + c + e + f) \right\} \frac{3}{8}$.

The following is Mr. Weddle's rule:* *Take seven equidistant ordinates. To five times the sum of the even ordinates add the middle ordinate and all the odd ordinates, and multiply the sum by three tenths of the common interval,* or area $= \left\{ 5\,(b + d + f) + d + a + c + e + g \right\} \frac{3}{10}$

In order to test the value of these rules we must compare the results obtained by them with those which are determined by exact calculation. Since the area of the common parabola is exactly two thirds that of the circumscribed rectangle, this area will afford a good example for comparison. Thus, let *o m k*, Fig. 4, represent a portion of a parabola whose equation is $y^2 = 4x$; or $y = 2\sqrt{x}$, *i e.*, each ordinate is equal to twice the square root of the corresponding abscissa. I have placed the equation in this convenient form in order that the reader may readily verify the following figures:




MEASUREMENT OF AREAS.

Since the area *o m k 7* $= \frac{2}{3}$ rectangle *o h k 7*, and area *o m 1* $= \frac{2}{3}$ rectangle *o l m 1*, therefore area *m 1 7 k* $= \frac{2}{3}$ (*o h k 7* — *o l m 1*). I have divided *m 1 7 k* into *six* spaces in order that all the rules may be tested by it.

For Simpson's first rule the number of intervals must be *even*, *e. g*, 6.

For Simpson's second rule the number of intervals must be a multiple of 3, *e. g.*, $2 \times 3$.

For Mr. Weddle's rule the number of intervals must be six, *i. e.*, 7 ordinates.

The area of the segment of the parabola *m 1 7 k* = 23.360 +.

The area measured by Simpson's first rule = 23.358 —.

The area measured by Simpson's second rule = 23 356 —.

The area measured by Mr. Weddle's rule = 23.359 +.

Mr. Weddle's rule gives the closest approximation. The error is less than 1 in 23.000.

In calculating the area of a figure bounded wholly by curved lines, as, for example, *a b c d*, Fig. 5, divide it into segments as follows: Draw the straight line *b c*, and *a e* parallel to it. Each segment, *a d e*, *a e c b* and *b f c*, may be measured separately, and the sum of these areas will give approximately the area required. It should be noted that in measuring the area *a d e*, the point *d* (= *o*) is treated as an ordinate. Also *b* (= *o*) and *c* (= *o*) must be treated as ordinates in measuring the segment *b f c*.

If the curve *b f c* is reversed, *i. e.*, if it takes the position of the broken line *b f' c*, the area of the segment *b f' c* should be deducted from, instead of added to, the sum of the segments *a d e* and *a e c b*.

* For a discussion of Simpson's rules, and note on Mr. Weddle's rule, see Williamson. Integral Calculus, Art. 148. Areas by Approximation.

## Remarkable Milling.

A remarkable job of milling machine work is being done at the Pratt & Whitney Co.'s shops at Hartford. The work is corrugating plates by milling, using gang mills, and finishing a plate at one cut. These plates are of steel $\frac{3}{4}$ inch thick, 24 inches wide and 40 inches long. The corrugations are formed of arcs of circles of $\frac{9}{16}$ inch radius, cover a surface 20 inches wide by 33 inches long, and are milled to a depth of $\frac{5}{32}$ of an inch, requiring a gang of mills 33 inches in length to do the work.

The plates are made for Spencer Kellogg, of Buffalo, N. Y., and so great has been the demand for them that the work has been going on 24 hours per day, using two sets of cutters, so that no time is lost while grinding.

One set of cutters is made up of 30 separate pieces, each 8 inches in diameter, $1\frac{1}{8}$ inches wide, and 4 inch bore, the faces of each being ground so that the joint will show as little as possible on the milled surface.

In the other set there are four pieces only, two of these contain each 9 of the corrugations, one 8 and one 7. They are interlocked, forming in effect a solid mill 33 inches in length, 8 inches diameter, and leaving a surface absolutely smooth. In locking, the pieces composing the gang are rotated upon the arbor to such relative positions that the teeth do not form a continuous line from end to end.

The plates are milled at the rate of about one an hour, including changing, and the mills, being kept well lubricated, run from 6 to 7 days without grinding.

The machine in which these mills are operated is built by the Pratt & Whitney Co., and known as "No. 7 double head power miller." It was designed and built to meet the requirements of work of this kind.

The present work, while not showing the result in cubic inches of stock removed per minute, as is shown in milling side rods and like work, is probably the severest test the machine has been put to, owing to the great length between centers, and amount of surface involved.

The work has been watched with great interest by mechanics visiting the company's works the past month, and astonishment expressed at the ease with which the work is done, the uniform smoothness of the milled surface, and the entire freedom from any evidence of chatter which might be expected in a gang of mills of this length.

## Calculating Weights for Estimates—IV.

BY J. HORNER.

There is really very little involved in the estimation of the weights of smiths' work, not nearly so much as in that of castings. For smiths' work is mostly in the form of, or reducible to the shapes of round rods, or flat bars, circles, and rectangular forms, for the estimation of which it is not always necessary even to bring the dimensions into cubic inches, the weights being obtainable from tables direct. The estimation of weights for smiths' work is therefore comparatively simple. Very irregular forms seldom occur, so that the estimation of the weights of forgings is done either by direct calculation or by the use of tables, or by both combined. Very much of the work of the smith involves the use of plain bars and rods, and the weights of these are given in tables for all diameters, per foot run, in iron and in steel, so that the work involves simple multiplication only. Further, in the case of many forgings of irregular shapes, portions of these forgings are plain bars and rods, which can be reckoned by the use of tables, the irregular portions only being calculated in detail. Even these, too, can often be reduced to plain rings, or disks, and their weights estimated by reference to tables. The rods, eyes, lever bosses, and similar forms can be reckoned in this way.

I do not think it necessary to illustrate any types of forgings. They are mostly so plain and of such elementary form that a verbal reference to them will suffice. On a few moments' reflection it will be difficult to call to mind any important forgings which are not built up, and referable to such simple forms as the rod of definite diameter; the flat bar, varying only in the relations of thickness and breadth, the bossed circular end on levers, or links, or weigh shafts; the circular boss located elsewhere than at the end; lumps, rectangular or otherwise, on the ends of rods, of which connecting rod ends may be taken as examples; forked ends of various types, cranks of circular section only, or combining circular sections with flat webs. A whole sheet of common forgings would not embody any other essential forms than these, and the weights of all of them can easily be obtained directly from tables, with or without some slight preliminary calculation. Thus, if a lever is tapered, the average width and thickness will be the sizes taken. The average diameter of a tapered boss will be taken. A forked end will be taken as solid if small, or if of large size the average section will be taken, and the length taken round the curve of the fork. A crank with some parts circular, and with flat webs, will be divided up accordingly, and the totals added together.

The calculation of weights for bridge, and girder, and structural work generally in wrought-iron and steel is relatively simple, being mainly a question of areas or of lengths; the weights of iron and steel plates, bars, angles, etc., being given in tables for all thicknesses. The principal calculations come in in estimating the areas of plates, nearly all others being questions of addition or multiplication.

In the case of all plates the area in square feet is obtained, and the weight of a square foot of a plate of that thickness, as given in a table, is multiplied by the number of square feet, thus obtained. The areas of plates are obtained by the rules of mensuration. All plated work is brought into simple forms for the estimation of square feet, as rectangles, triangles, circles, irregular forms being divided up into sections most suitable for calculations. The plates which form the envelopes of curved surfaces, spherical, conical, or otherwise, are developed and then calculated, or their areas are estimated by the rules of mensuration appropriate thereto. The thicknesses of the plates supply the other data for the weight, for which purpose a table of weights of plates 12 inches square of the usual thicknesses employed in the shops is to be consulted.

In the work of platers and boiler makers the estimation of weights involves three classes of calculation. First, the areas of *plane surfaces*. Second, the areas of the *enveloping surfaces* of solid or hollow bodies. Third, the *volumes* of solid or hollow bodies. The calculation of these requires a knowledge of the rules of mensuration, which are given in all arithmetics, and in most pocket reference books. The dimensions of work are taken either in feet or inches, and where there are fractional parts it is easier to make use of decimals than of vulgar fractions.

When the edges of plates are not straight, but curved to a greater or less extent, then the work is divided into short lengths, and the widths of each section averaged, and the several sections added together.

The estimation of the weights of bars, both round and square, is taken directly from tables. It is simply a question of width and thickness and length of 12 inches multiplied by the number of feet run in bars of the given section. In the case of the other rolled sections, angles, tees, channels, joists and other irregular forms, the weights are usually taken direct from tables, either given in books of reference, or in the maker's list, or they may be calculated. The weights of channels and joists of given dimensions are nearly always taken directly from the manufacturer's price lists. Angles and tees vary so greatly in width and thicknesses, however, that an exhaustive table of weights of these would make a bulky volume. Only the weights of some of the commoner angles and tees are therefore given in engineers' books of reference. It is therefore most usual to estimate the weights of these by calculating their *united inches*, and then reckoning out the weight per foot run. By "united inches" is meant the total number of square inches in the cross-section. Thus an angle measuring

5″x5″x1″ would have 9 united inches in its cross-section, and the weight of such an angle per foot run would be nine times that of a bar 1 foot long and 1 inch square. So that having found the number of square inches in any given section, it is only necessary to consult any table which gives the *sectional areas of bars*. It does not matter whether the bars are round or square, so long as the sectional areas in square inches are given. The same remark applies to other sections besides angles and tees. But in many cases, as with channels and joists, it is usual for the manufacturers to issue price lists containing the weights per foot run of the various sections of joists and channels in iron and steel which they supply, and these can be utilized in estimating weights. The weights of all rolled sections are easily reckoned in one of these ways.

There are little items in work which are apt to be either overlooked, or under-calculated in estimates. These are bolts, screws, studs and rivets. Very often these are not shown in small scaled detailed drawings, or a few only are indicated by center lines. Often too in large detail drawings one is apt to overlook a good number of them unless a minute and careful calculation is made. Perhaps a set-screw is shown in a detail, but the number required may have to be reckoned out by addition or multiplication. Especially is this the case in riveted work. Unless one is very careful it is easy to omit a large number of rivets from a drawing of girder work, involving many different views, and items of detail. The lines of rivets have to be picked out, and their total lengths divided by the pitch. It is surprising what an enormous number of rivets are wanted on this class of work. In the case of rivets the usual practice is to weigh a rivet of the dimension required, and multiply that by the number of rivets required.

Some useful multipliers suitable for smiths and plated work are tabulated below.

For the weight of round bars in pounds avoirdupois: Square the diameter in inches, multiply by the length in feet and the product by 2.63 for iron, and by 2.67 for steel.

For the weight of square bars in pounds avoirdupois: Multiply the area of the cross-section in inches by the length in feet, and the product by 3.36 for iron and by 3.4 for steel.

The weight of a plate of wrought-iron 12″x12″x1″ thick averages about 40 pounds.

Therefore the thickness of any plate a foot square, given in inches and fractions of an inch, × 40 = pounds weight per square foot.

The thickness in eighths of an inch × 5 = pounds per square foot. The thickness in tenths of an inch × 4 = pounds per square foot.

Square feet one inch thick must be multiplied by 40 to obtain the weight in pounds in wrought-iron, by 40 8, or, say, 41, to obtain the weight in steel.

When the volume in cubic inches is given to find the weight in pounds, multiply by .278, or by .28 for wrought-iron, 283 for steel.

It is often desirable to be able to deduce the weight of a piece of work in one material from the weight of a piece of work in another material, as copper from wrought-iron, steel from wrought-iron, and so on. Tables of comparative weights are available for this purpose, and will be found in most engineers' books of reference.

When there is a good deal of work involved in an estimate it is necessary before commencing to go through the details to make a careful list of all the several items. These may amount to many scores or even hundreds. But if this is not done, some parts are apt to be omitted when going through the details. But besides this, the time spent will not be wholly lost, because the working through the drawings in order to pick out the several items will fix the whole of the job well in the mind, and so facilitate the after calculations.

Further, when setting down the several items, the castings should be reckoned out separately, and the castings in different materials, iron, steel, gun metal, etc., distinct from one another. Then the plates should be tabulated distinct, then angles, tees, joists, shafts, forgings, rivets, bolts, timber, india rubber, chains, ropes, copper, or other piping. And in each class the dimensions of each several piece should be jotted down, as length, width, and thickness of each piece of plate, with its weight opposite it, the length of each angle, with the width and thickness of its flanges and its weight. When all is done, the results should be tabulated neatly in columns, so that any important omission can be readily detected.

## MANUFACTURES

The Wendler Machine Co., Carthage, N. Y., are about to build a brass foundry.

The Maine Manufacturing Company, manufacturing refrigerators, lap-boards, screens, etc., at Fairfield, Me., will build a large plant at Nashua, N. H.

The Westinghouse Electric Company will construct a plant to employ 1,000 hands at Allegheny City, Pa. The plant will be used for incandescent lamp making, and 20,000 will be produced each day.

A $100,000 cotton-mill plant may be erected at Winston, N. C., during the coming six months. The Winston-Salem Chamber of Commerce is interested.

Randolph & Clowes, of Waterbury, Conn., have placed the contract for the extension to their muffle room with The Berlin Iron Bridge Co., of East Berlin, Conn.

Messrs. A. F. Sanborn & Co. have commenced to build their lumber dryhouse at Steep Falls, Maine.

They will have to purchase a new engine, as the old one was ruined by fire.

The contract for the electric lighting plant for the new steamer of the Portland Steam Packet Company has been awarded to the Belknap Motor Company, of Portland, Me.

Reeves & Company, manufacturers of threshers, engines, etc., have leased, for a term of years, the large buildings on South Tennessee street, Indianapolis, Ind., recently occupied by Blair & Baker.

President Bennett, of the Indianapolis Stove Company, states that the company is now working 100 men out of the usual 130. He said their sales were exceeding 1893, but not up to those of 1894.

The outlook is favorable that the St. Stephen (N. B.) broad-axe factory, which has not been operated for some time, will be resumed by a stock company, thus re-establishing the industry in St. Stephen.

I. Varney & Sons, the North Berwick (Maine) machinists, are building a steam saw-mill in connection with their machine shop on the northwest side, and very near the B. & M. track, where they will do custom sawing of all kinds.

Hetherington & Berner, of Indianapolis, have been awarded the contract for the iron work in the new building of the Rumely Manufacturing Company, of same place, in the construction of which sixty or more tons of iron work will be used.

D. Saunders' Sons, Yonkers, N. Y., manufacturers of gas and steam fitters' tools, are putting up a new building for storage and to accommodate their blacksmith and pattern shops. They are replacing wooden buildings with brick ones, measuring 50x40 feet and 50x70 feet.

Mr. J. Erlandsen, 170 Centre street, New York, sends us a small pamphlet containing illustrations and description with prices of various forms of milling cutters, manufactured, kept in stock, and made to order by him. The pamphlet is sent to any address upon application.

Rumely & Company, manufacturers of threshers, engines, etc., have torn down the old frame building they have occupied for some years on the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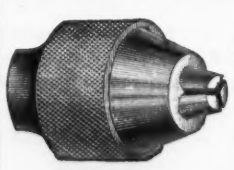

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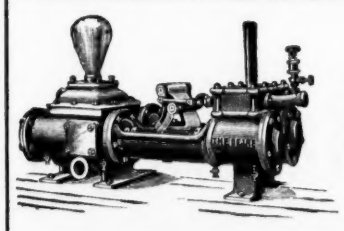

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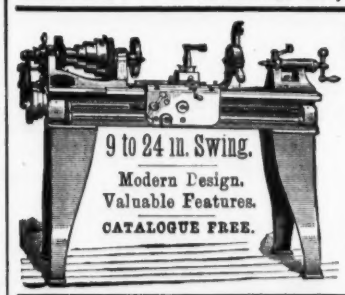


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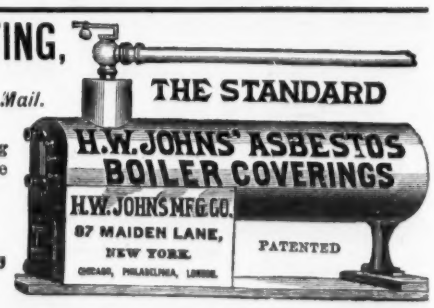

corner of Tennessee and Georgia streets, Indianapolis, Ind., preparatory to erecting a three-story brick building covering the entire ground.

We have received from Beaman & Smith, Providence, R. I., a special pamphlet containing illustrations and descriptions of a variety of work which can be done with their No. 1 horizontal spindle, drilling and boring machine. The pamphlet will be found of interest to those concerned with such work, and is sent upon application.

The new power station for The Nassau Electric Railway Co., at Brooklyn, N. Y., will be 102 feet wide and 150 feet long, and will be constructed entirely of iron and steel, the whole designed and built by The Berlin Iron Bridge Co., of East Berlin, Conn. The roof will be covered with their well-known patent anti-condensation corrugated iron roof covering.

The Rumford Falls (Maine) Light and Water Company are enlarging the capacity of their works. Their 500-light machine is taxed to its full capacity, and there is a demand for 300 more lights. The company will soon put in two 1,000 light machines, and an additional power generator. The course of the line is being changed to new poles across Canal bridge and along Railroad street.

Advices from T. J. Neacy, manager of the Filer & Stowell Company, the widely known manufacturers of high grade saw-mill machinery, Milwaukee, Wis., are to the effect that they have enough orders on hand to keep them comfortably full for the next three months. They are adding to their erecting shop, the addition being 140x80 feet. This will give them a floor space of 250,000 feet.

The Cleveland Machine Screw Co., Cleveland, Ohio, are building a new machine shop, 40x250 feet, for the manufacture of their automatic screw machines on a larger scale. The building will be either 3 or 4 stories high, but which is not yet decided. The lower floor will be equipped with traveling crane. An office building with drawing room above is also being erected. This company has taken orders for 59 screw machines during the past two months.

We have received from the Link-Belt Engineering Co., Chicago, Ill., a very elegantly gotten up catalogue, entitled "Modern Methods of Handling Fuel as Practiced in Locomotive Coaling Stations, Electric Light and Street Railway Power Plants, Etc." Numerous illustrations are given of typical plants, and the pamphlet will be found of considerable interest to all who are interested in handling fuel in large quantities. It is sent to those interested upon application.

The new company which takes the Indianapolis Cabinet Works will not manufacture their own veneering. It is stated that one of the great leaks with the works when under the Coffins was the department of veneering, which only the most experienced can manufacture with profit. Indianapolis has become quite noted in this industry. The Pullman Company for years has purchased most of its veneering from our manufacturers. There are two large veneering manufactories here, and they have a capacity to turn out 12 million feet a year. —*Indianapolis Journal.*

We have received the prospectus of The Holmes Fibre-Graphite Manufacturing Co., Philadelphia, Pa., which numbers among its officers and directors a number of very well-known engineers and manufacturers. The prospectus gives an account of the results obtained with the Holmes lubricating bearing, a report of the Franklin Institute upon the bearing, etc. Accompanying this is a pamphlet from the Link-Belt Engineering Co., Chicago, Ill., giving illustrations of journal bearings, shaft hangers, etc., fitted with bearings of Holmes fibre graphite. These will be found of interest to those concerned with matters of power transmission especially.

A press dispatch from Whitestone, Long Island, dated October 23d, says: Business in the two leading manufactories of this place—those of the Norton Can Company and the Central Forge Company—has taken a decided change for the better. The can factory, which for months has been on the verge of closing down, having laid off over half of its employes and working the rest on greatly reduced time and wages, has now on the pay-roll 210 hands, which is an increase over the number employed in good business times. Because of the great and constantly increasing influx of orders, the company has been obliged to keep the whole force working until 10 o'clock each night for the last two weeks. The Central Forge Works, whose business has also been stagnated for a long time, is experiencing the greatest rush in work that it has had in years. All of the hands laid off when the dull times set in have been taken on, and, in addition, a large night force has been employed. The works are running full blast night and day.

A press dispatch says: There is an apparent revival of business in many of the manufacturing concerns in Hartford. The Pope Manufacturing Company has 725 men employed on full time, and several departments working until 10 P. M. The Hartford Woven Wire Mattress Company is employing 150 men, 30 more than six months ago, with some departments running three hours' overtime a day. The Pratt & Whitney shops have 800 men working full time. The Collins Company, of Collinsville, makers of axes and cutlery, has 600 hands on full time. Two hundred and fifty hands are employed by the Plimpton Manufacturing Company, envelope makers, on full time, and the Pratt & Cady Company, steam valves, has now 315 men employed 10 hours a day. Almost all the factories have many more men employed than six months ago, and have dropped the short time schedule which has prevailed for nearly a year. A similar revival of manufacturing business in Meriden, Bridgeport, and other manufacturing cities in the State is reported.

*The Tradesman*, Chattanooga, Tenn., in its report on the industrial condition of the South for the week ending October 29th, says: Increasing demand and more firmness in prices is reported for Southern lumber, and especially for Louisiana cypress, which is now in very general use. Low-priced cotton is retarding sales, as the planters are in better condition than ever before, and can hold their crops. The steady demand for Southern iron, which prevents accumulation of stocks in the furnace yards, is attracting much attention. Money is easy and mercantile business fairly good. *The Tradesman* reports forty-one new industries as established or incorporated during the week, the most prominent among them is a $600,000 cotton-mill at Rome, Ga.; one is also reported at Carrollton, Ga., and one with $50,000 capital at Laredo, Tex. The Emporia Lumber Co., capital, $100,000, has been chartered at Houston, Tex.; a coal mining company, with $100,000 capital, at Montgomery, W. Va., and a $50,000 compress company at Galveston, Tex. The Admant Manufacturing Co., capital, $50,000, has been chartered at Van Buren, Ark., and an engineering and construction company with the same capital at Macon, Ga. Gainesville, Texas, reports a harness manufactory, with $30,000 capital; a $30,000 coal and coke company has been chartered at Mt. Hope, W. Va.; a $15,000 grain elevator is to be built at Mobile, Ala., and a


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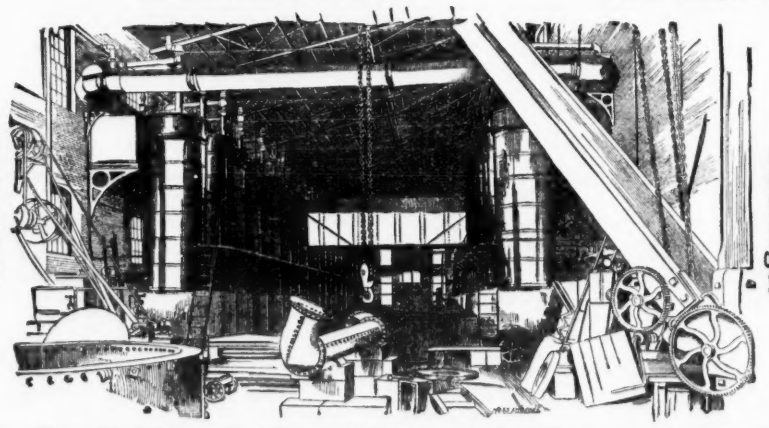

The above illustration is taken direct from a photograph, and shows the interior of a Boiler House, the roof of which was designed and built by us for the Amoskeag Mfg. Co., at Manchester, N. H. The building is 75 feet in width by 275 feet in length, the walls being made of brick, and the roof being made of iron—iron trusses, iron purlins—and covered with corrugated iron, so that there is absolutely no woodwork anywhere about the building which can take fire. For boiler rooms this construction particularly commends itself.

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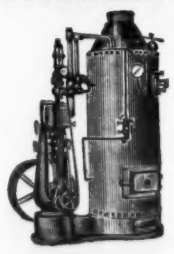

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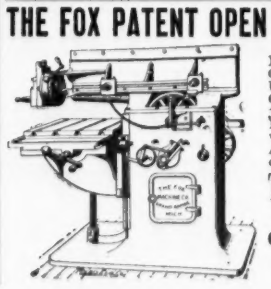

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| 8 | 1 1-4 | .80 |
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| 10 | 1 1-2 | .95 |
| 11 | 1 3-4 | 1.10 |
| 12 | 2 | 1.20 |
| 13 | 2 1-4 | 1.35 |
| 14 | 2 1-2 | 1.45 |
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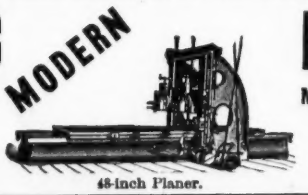

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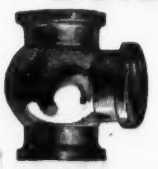
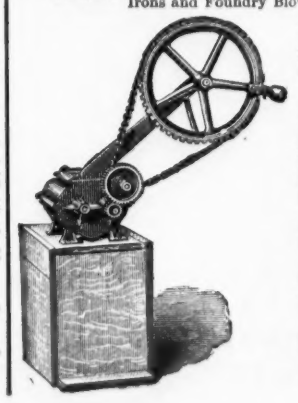


GLOBE SPECIAL CASTINGS FOR WATER-WORKS,
MILLS AND RAILROADS.
"I think they are the most practical special in use at the present time."
All common sizes in stock. Catalogue mailed on application.
M. J. DRUMMOND, SALES AGENT, 192 BROADWAY, NEW YORK CITY.

ROOTS' NEW ACME HAND BLOWER.
For Blacksmiths, etc. Slow Speed, Positive Blast. Is Durable, Compact and Cheap; also Portable Forges, Tuyere Irons and Foundry Blowers.



P. H. & F. M. ROOTS, Mfrs.
CONNERSVILLE, IND
Chicago Office: 1405-10 MANHATTAN BUILDING.
S. S. TOWNSEND, Gen. Agt. } 163 & 165 Washington St., NEW YORK.
COOKE & CO., Selling Agts. }
Please Mention This Paper.

WORTHINGTON CONDENSER.
ONLY APPARATUS that can MAINTAIN a VACUUM on ENGINES and ELEVATE the discharge WATER to TANK at any height.
This feature is appreciated by PAPER MILLS, SUGAR REFINERIES, COTTON and WOOLEN MILLS.
HENRY R. WORTHINGTON,
NEW YORK, 86 and 88 Liberty St.
BOSTON, 70 Kilby St.
PHILADELPHIA, 607 Arch St.
CLEVELAND, 24 South Water St.
CHICAGO, 185 to 189 Van Buren St.
ST. LOUIS, Eighth and St. Charles Sts.

$10,000 ice factory at Roanoke, Va. A canning factory will be built at Dyersburgh, Tenn.; car works are reported at Fort Worth, Texas, and flour and grist-mills at Eufaula, Ala., Somerset and Winchester, Ky., Crawford, Tex., and Parkersburg, W. Va. *The Tradesman* also reports the opening of coal mines near Birmingham, Ala.; of lead and zinc mines at Broadway, Va., and of a marble quarry at Dadeville, Ala. A cordage factory is to be built at Charleston, S. C.; a paper pulp mill at Chattanooga, Tenn.; a soap factory at Ashland, Ky., and tobacco factories at Louisville, Ky., and Martinsburg, Va. The new woodworking plants of the week are at Mobile, Ala., Cordele, Ga., Manchester, Ky., Greenville, S. C., Chattanooga, Tenn., and Camden-on-Gauly, Central City and Hulings, W. Va. Water-works are reported at Bentonville and Monticello, Ark. Among the enlargements for the week, as reported to *The Tradesman*, are flouring mills at Paisley, Ky.; iron works at Wheeling, W. Va.; paint works at Columbia, S. C.; tobacco factories at Martinsburg, Va., and woodworking plants at Jeanerette, La., and Fredericksburg, Va.

### Machinists' Supplies and Iron.

New York, November 1, 1894.

Iron—American Pig—We quote standard brands, $12.25 to $12.50 for No. 1; $11 to $12 for No. 2. Southern brands, $11.50 to $12 for No. 1; $10.50 to $11.25 for No. 2; $10.25 to $10.75 for No. 3; $10.75 to $11 for No. 1 soft; $10.50 to $10.75 for No. 2 soft; and Foundry No. 4, $10 to $10.40.

Antimony—There is a fair demand. We quote L. X., 8¼c. to 8½c.; Cookson's, 9.40cc. to 9.50c.; Hallett's, 7¼c. to 7⅜c.; and U. S. French Star, 9¼c. to 9½c.

Lard Oil—Prime City we quote at 59c. to 60c.

Copper—The market has a firmer tendency, otherwise there is no change of importance. The Lake companies would sell at 9¾c., but second-hand copper can be bought at 9⅝c. Casting Copper is held at 9.20c. to 9.25c.

Lead—The prices have remained nearly stationary. The market if anything is a little firmer. We quote 3.10c. to 3¼c. for New York delivery.

Spelter—The demand continues light, and a moderate business only has been transacted; ordinary Western brands are quoted at 3.40c. to 3.45c. for New York delivery.

Tin—The market is steady; purchases of fair-sized lots made up a good volume of business. For spot, 14.90c. is asked.

## WANTED

*"Situation and Help" Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.*

Constructor and inventor, printing presses, spe'l mach'y, open for contr't Jan. 1st. H.C.F., Am. Mach.

A mach. shop supt. of superior ability desires to make a change; cor'd'e solic'd. Box 25, Am. Mach.

Mass. Inst. Tech. graduate in mechanical eng., wants position. Address Box 163, Taunton, Mass.

Draftsman, grad., 6 years' exp. in eng. and boiler work, wants position. Box 7, Am. Machinist.

Wanted—Mechanical, electrical engrs., draftsmen; professional work for leisure time. Edwin Guthrie, Corcoran Building, Washington, D. C.

Mech. eng'r with 12 years practical experience in designing of steam and general mach'y, member of A. S. M. E., is open for pos. Box 37, Am. Mach.

A mechanical engineer, with experience in designing and constructing light mach'y, tools and fixtures, wants a pos.; age, 36. Box 30, Am. Mach.

As business manager of machine works. Wanted a first-class pos. by gentleman who is thoroughly practical in all the departments, able and reliable in business matters; 30 years exp., covering many lines of machinery; unexceptionable references. R. Wadsworth, 801 63d street., Englewood, Ill.

Wanted- Situation by foundry foreman, age 38, with 22 years successful experience on general work, largely engine and saw-mill work, 12 years as foreman: understands pattern system, accustomed to systematic methods. Small town preferred to large city. A1 references. Address Box 26, American Machinist.

## ✢ MISCELLANEOUS WANTS ✢

*Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.*

Cheap 2d hd lathes & planers. S.M.York, Clev'd O.

Auto. Steam Flue Cleaners. Kelley Co., Erie, Pa.

Calipers & Gauges. F. A. Welles, Milwaukee, Wis.

For Sale—Second-hand drill presses, engine lathes & planers. Dietz, Schumacher & Co., Cincinnati, O.

Light and fine machinery to order; Foot Lathe Catalogue for stamp. E. O. Chase, Newark, N. J.

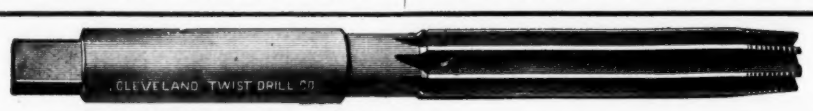
Wanted—To buy good second-hand tools. Box 83, American Machinist.

Draftsmen's new conveniences for rapid work. Send for blue print. D. J. Kelsey, New Haven, Ct.

Model Locomotive Castings. Latest design. G. H. Olney, 163 Herkimer street, Brooklyn, N. Y.

Every mechanic should have a copy of "Pocket Primer of the Air Brake." Sent to any address for 50 cents. W. S. Rogers, Buffalo, N. Y.

Machine tools wanted—Either new or 2d-hand. If latter, must be in first-class condition. One 20" shaper, one 24x24 planer, with about 6 feet bed. Address Lock Box 147, New Brunswick, N. J.

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COR. LAKE & KIRTLAND STS. CLEVELAND, O.

100 & 102 Reade Street, New York.
85 Queen Victoria St., London, Eng.
5 Neue Promenade, Berlin, C., Germany.

**DETROIT TWIST DRILL CO., DETROIT, MICH., U. S. A.**

SOLE MANUFACTURERS OF

**GRAHAM'S GROOVED SHANK TWIST DRILLS AND CHUCKS.**

Endorsed by Practical Mechanics Everywhere. Send for Catalogue.

## Machine and Boiler Tools,

MODERN STYLE, AT LOW PRICES.

**IRON PLANERS.**

19 in. x 3 ft. Wheeler.
20 " x 6 " Pratt & Whitney.
22 " x 5 " Pease.
24 " x 4 " Wood & Light.
24 " x 5 " New Haven.
24 " x 6 " Wood & Light.
26 " x 7 " N. Y. S. Eng. Co.
27 " x 5 " Pond.
30 " x 10 " Bancroft heavy A1
36 " x 12 " Powell.
60 " x 24 " Steam Eng. Co.

**SHAPERS.**

9 in. Stroke Hewes & Phil.
9 " " Gould.
16 " " Gould & Eber.
22 " " Triple Geared.

**DRILLS.**

1 Spindle Imp. Sensitive.
20 in. Swing Wheel Feed
25 " " Prentice complete.
48 " " Old Style
Radial Drills 54 and 66 in.
Universal Radial 96 in.

**MILLING MACHINES.**

Brown & Sharpe No. 6 Plain.
Brainerd Plain Table 30 x 8.
Brown & Sharpe No 1 Universal.
Lincoln Pattern, very cheap.
Garvin, No 2 and 4.

**BORING MILLS.**

Bement No. 2 Hor., B. & D.
Bement Cyl. Borer, 12 to 36 in.
Upright B & T. Mill, 38 in.
Brown & Sharpe Upright Turret Borer, takes in 36 x 12 in.

**ENGINE LATHES.**

13 in. x 6 ft. Blaisdell.
14 " x 6 " Reed Taper.
15 " x 5 " Pond.
15 " x 8 " Standard.
16 " x 6 " Ames.
16 " x 6 " Putnam.
18 " x 8 " Standard.
20 " x 10 " Fitchburg
20 " x 12 " Prentiss Taper.
22 " x 10 " Putnam.
24 " x 12 " Putnam.
30 " x 16 " Perkins.
35 " x 15 " Hewes & Phillips.

**HAMMERS.**

100 lb. Stiles "Fric. Drop."
800 " "Steam" Ferris & Miles.

**BOILER AND BRIDGE TOOLS.**

Rolls 7, 8 and 10 ft.
Hor. Flange Punch, "H and J."
Bement Plate Planer 16 ft.
Allen Pneu. Bridge Riveter with reach of 60 in.
Allen Bridge Riveter, 25 in.
" " " 34 "

**MISCELLANEOUS.**

Imp Brass Cabinet Turret.
Acme, 1 in. Bolt Cutter with Dies, Nut Taps, Chuck etc.
Slotters 10 and 18 in. Stroke.
Gear Cutter 36 in., ex. heavy.
Screw Machine, 2 in. hole.
Screw Machine No 2. Wire feed.
Cutter and Reamer Grinder "Putnam's." Good as new.
Universal Grinder No. 1, all atts.

**J. J. McCABE,**

SUCCESSOR TO
E. P. BULLARD'S
N. Y. Mach'y Warerooms.

14 Dey St., NEW YORK.

## MACHINERY BARGAINS.

10 in. Post Drill.
10 " " Auto. Feed to Table.
" for Butt Drilling.
1, 2 and 3 Spindle Sensitive with and without Power Feed.
2, 3 and 4 Spindle Gang Drills
20 24, 26, 28, 30 and 44 in. "
60 in. Swing Post Drill.
5 ft. Arm Radial Drill.
12 in. Stroke, 16 in. x 16 in. Crank Planer.
16 in. x 4 ft. Planer.
24 " 4, 5 and 6 ft. Planer.
28 " 5 and 8 " "
30 " 5, 8 and 10 " "
60 " 20 " "
72 " 25 " "
9, 12, 16 24 and 26 in. Stroke Shaper.
10 in. Stroke Slotter.
Hyd. Riveting Machine.
" Crane, Both A1.
Punch and Shear.
Plate Planer.

Hor. Flange Punch No. 2 H. & J. Thomson Bevelling Shear.
15 " 6 and 8 ft. Eng. Lathe.
16 " 5 6, 7 and 10 ft. Eng. "
18 " 6 7 and 8 " "
20 " 5, 6, 7, 8 and 10 ft. " "
21 " 10 and 13½ ft. " "
24 " 10 " " "
25 " 16 and 24 " " "
32 " 16 " " "
52 " 35 " " "
57 in. Double Head Driving Wheel Lathe.
88 in. x 20 ft. Engine Lathe.
Bement Car Axle Lathe.
1¼ & 2 in. Bolt Cutter Schenk's.
7 Spd'l Nut Tapper, Dunel.
2 Spd'l Profiler, No. 1 P & W.
No. 1, 2 and 2½ Screw Machs. P. & W.
No. 1 Lincoln Pattern Miller.
Hand Millers, Screw Slotters, Mill and Cutter Grinders.
No. 2 Garvin Universal Miller.

Lot of Miscellaneous Machinery, Engines, etc. Send for Latest List.

**GEO. PLACE MACHINE CO.,**

Offices: 145 BROADWAY and 86 LIBERTY ST.
Warehouse: 511 and 513 WEST 13th STREET,
NEW YORK.

## WANTED

TO BUY FOR CASH.

First-class Second-hand Engine Lathes, Planers, Drill Presses, Shapers, Milling Machines, etc., address,

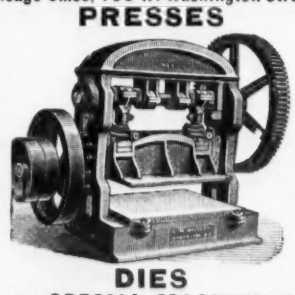
The Fosdick & Plucker Machine Tool Co.,
CINCINNATI, OHIO.

IF YOU WANT ANYTHING IN THE LINE OF
DROP PRESSES · DROP HAMMERS · STAMPS
OR AUTOMATIC DROP LIFTERS.
SEND FOR CATALOGUE TO
Miner & Peck Mfg. Co.
NEW HAVEN, CONN.
LARGEST LINE IN THE MARKET

**E. W. BLISS CO.**

1 ADAMS ST., BROOKLYN, N. Y.
Chicago Office, 100 W. Washington Street.

PRESSES



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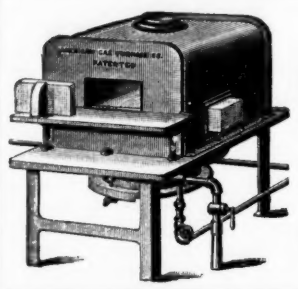
DIES
AND SPECIAL MACHINERY.
The STILES & PARKER PRESS CO.

## COLD SWAGING MACHINE

The Dayton Swaging Machine is the best for reducing and pointing wire and tubing. If interested address the manufacturers,

EXCELSIOR NEEDLE CO.
Torrington, Conn.



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## Oil Gas Plants

GAS BLAST FURNACES AND HIGH PRESSURE BLOWERS

For the economical generation and systematic application of HEAT.

CATALOGUES ON APPLICATION.

**No. 80 Nassau St., NEW YORK.**

English Agency: {Chas. Churchill & Co., Ltd., 21 Cross St., Finsbury, London, E. C., England.

## SECOND-HAND MACHINE TOOLS.

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16 in. x 6 ft. Blaisdell.
16 in x 8 ft Perkins, Taper.
16 in x 8 ft. Blaisdell.
18 in. x 6 ft New Haven.
18 in. x 6 ft. Bradford.
18 in x 8 ft Blaisdell
18 in. x 8 ft. Wamesit.
18 in. x 10 ft. Blaisdell.
18 in x 9 ft. D. W Pond.
20 in. x 6 ft. Bullard.
24 in. x 12 ft Geo. Gage.
29 in. x 12 ft. Fifield.

**PLANERS.**

16 in. x 16 in. x 3 ft. Walter Bros.
20 in x 20 in. x 5 ft. Ames.
22 in. x 22 in. x 4 ft. L. W. Pond.
24 in. x 24 in. x 6 ft Whitcomb.
24 in. x 24 in. x 5 ft. Putnam.
28 in. x 28 in. x 7 ft. New Haven.

**SHAPERS.**

10 in. Juengst Crank.
10 in. Wood and Light Traverse Head.
18 in. Putnam Traverse Head.
24 in Hendey Friction

**HAND LATHES.**

4 10 in. x 41 in. Garvin.
1 12 in. x 4 ft. Garvin.
1 12 in. x 5 ft. Back Geared.
1 20 in x 6 ft. Back Geared.

**MISCELLANEOUS.**

Garvin Profiler, one Spindle.
6 in. Bement Slotter.
36 in. Gould & E. Automatic Gear Cutter.
26 in Pulley Lathe.
50 in. Pulley Lathe.
5 in Cutting-off Machine.
No 2 Springfield Tool Grinder.
No. 1 Garvin Screw Machine.
3 in. Squaring Shear.
14 ft. Power Draw Press.
250 lb. Gould & Eb Drop Press
No. 2 Garvin Cutter and Drill Grinder
No. 1 Sl te Marking Machine.
No. 2 Garvin Automatic Tapper.
No. 4 Sturt vant Blower.
Garvin Wire Spring Coiler.
Several Wood-working Machines.

Also, a large number of other machines. Write for complete list and detailed description.

**THE GARVIN MACHINE CO.,**

LAIGHT & CANAL STS., NEW YORK.
Also, 51 North 7th St., Philadelphia, Pa.

## NEW AND SECOND-HAND MACHINE TOOLS.

**ENGINE LATHES.**

14 in. x 6 ft. Lodge & Davis.
16 in. x 6 ft. Lodge & Davis.
19 in. x 6 ft. Pratt & Whitney.
21 in. x 11 ft. Lodge & Davis.
24 in. x 12 ft. Special heavy pattern.
24 in. x 12 ft. Standard.
24 in. x 16 ft. New Haven.
28 in. x 17½ ft. New Haven.
24 in. x 38 ft Shafting Lathe.
12 in. x 4 ft. Manhattan Co.

**TURRET LATHES.**

3 12 in. and 2 15 in. Lever and Screw Movement to Turret.
1 22 in. x 8 ft. Chucking

**PLANERS.**

24 in. x 24 in. x 8 ft. Lodge & D.
24 in. x 24 in. x 8½ ft. Putnam.

**SHAPERS.**

15 in. Crank.
20 in. Geared.
26 in. Geared.

**DRILL PRESSES.**

20 in. Lever Drill.
24 in. B. G. P. F. Drill.
26 in Post Drill.
52 in. Comb. Radial.
80 in. Comb. Radial.
120 in. Radial.
1 Breast Drill.

**MILLING MACHINES.**

No. 2 and No. 4 Garvin.

**MISCELLANEOUS.**

2 No. 1 Garvin Tapping Mach.
1 No. 2 Garvin Tapping Mach.
1 Open Die Header for Heading Bicycle Spokes.
1 Garvin Screw Slotter.

PULLEY MACHINERY, BRASS WORKING MACHINERY.

**THE LODGE & SHIPLEY M. T. CO.,**

CINCINNATI, O.

OVER 12,000 IN USE.

**"COLUMBIA" VERNIER CALIPERS, Etc.**

Graduated in Inches or Metric System.
Using them results in Better and More Work!

Send for Catalogue and Special Prices to E. G. SMITH, Columbia, Pa.

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Pat'd May 14, '89. Sept. 4, '94.

Is the original (not copied) device for holding and driving Straight or Taper Shank Drills. No More Twisted Tangs. No extra cost for Andrew's Patent Groove in the Shank. Best Practical Drill Chuck in the World. No change in the old system of drills. Beware of frauds and infringements. Send for Catalogue.

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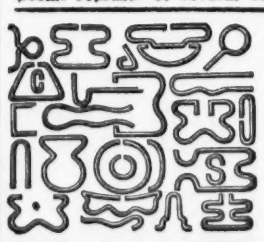

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BUILDERS OF

**PIN, SAFETY PIN, HOOK AND EYE MACHINERY,**

AND LABOR-SAVING MACHINES OF EVERY DESCRIPTION.

*Bent Wire Goods a Specialty. Send Samples that we may quote prices for either machine or the Goods.*

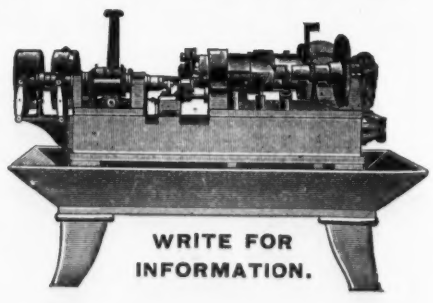
## STEEL BALLS

For all Anti-Friction Purposes.

WE ALSO MANUFACTURE

**AUTOMATIC SCREW MACHINES**
AND
**SCREW MACHINE PRODUCT**
OF EVERY DESCRIPTION.

**Cleveland Machine Screw Co.,**
CLEVELAND OHIO.



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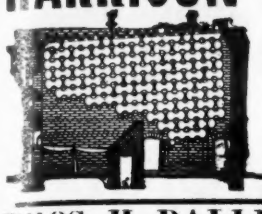

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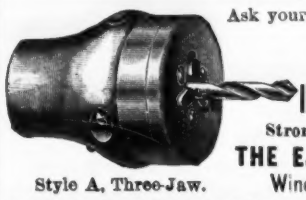
Ask your nearest Dealer, or send to the Manufacturers for



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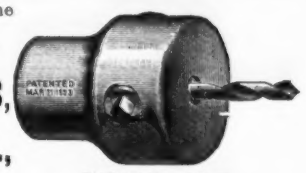
Strong, Accurate, Durable, Cheap.
THE E. HORTON & SON CO.,
Windsor Locks, Conn., U. S. A.



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Or CHAS. CHURCHILL & CO., Ltd., 21 Cross St., Finsbury, London, Eng. Awards at the World's Fair.

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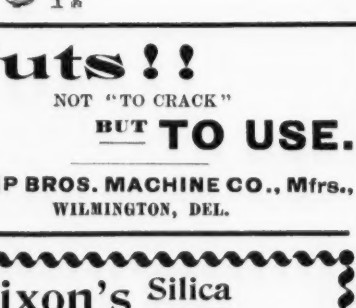
MANUFACTURERS OF
ELECTRIC MOTORS
Specially adapted for driving Machine Tools, Cranes, Elevators, Pumps, Presses, and other Machinery.



We also make
Portable Drills, Hand Drills, Boiler Shell Drills, Light Drill Presses.

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FOR HAND OR ELECTRIC POWER.

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MANUFACTURERS OF
TRAVELING CRANES of 1½, 2, 3, 5 and 10 Tons capacity, to be operated by Hand, or wholly or in part by Electricity.

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For Lathes, Drills, Chucking and Screw Machines, and for Special work. . . . . .
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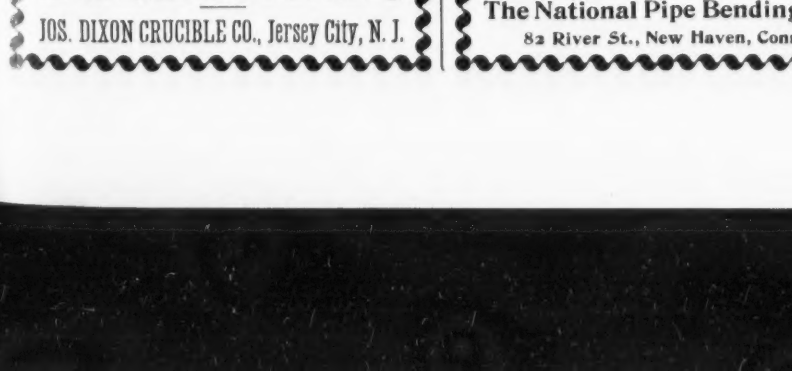
NORTON Emery Wheel Co.
Worcester, Mass.
NEW COMPLETE ILLUSTRATED CATALOGUE FREE.



# HIGH SPEED POWER
TRAVELING CRANES
Driven Either by Rope or Belt, or by Electric Motor.
MANUFACTURED BY
ALFRED BOX & CO.,
Front, Poplar and Canal Sts.,
PHILADELPHIA, PA.
Send for Circulars and References.

CRANES, TROLLEYS, PORTABLE HOISTS, OVERHEAD TRACK.
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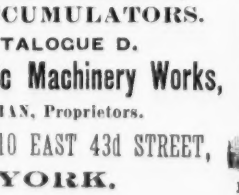

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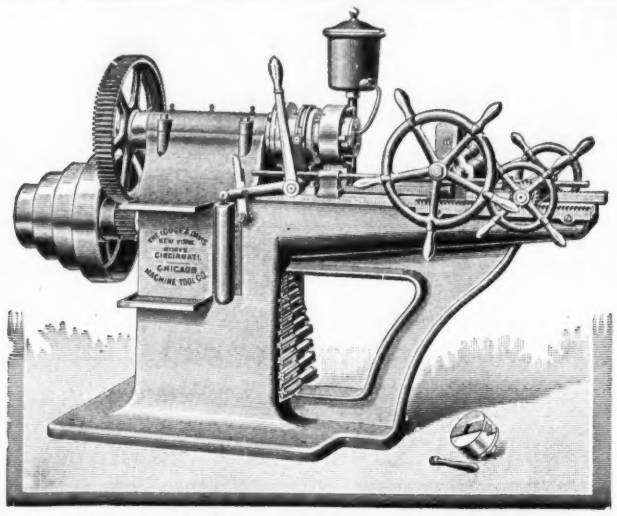

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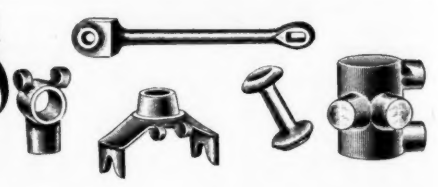

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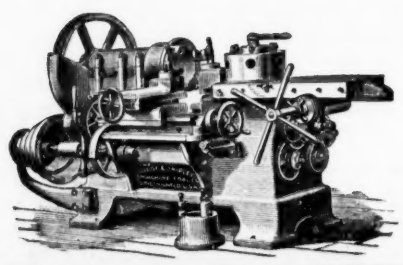

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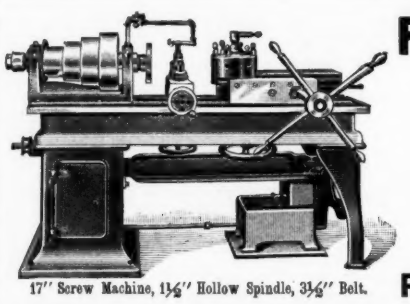

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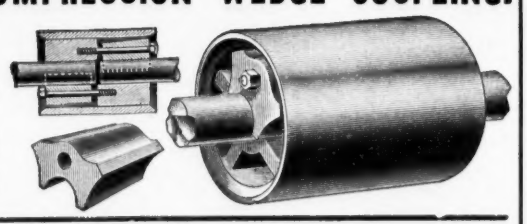

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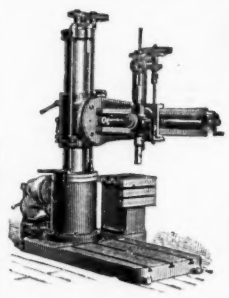

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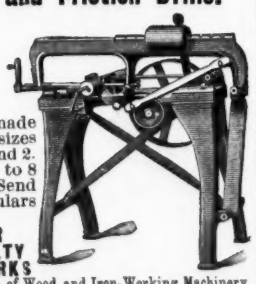

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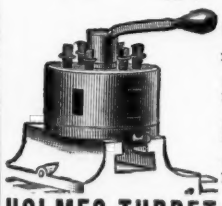

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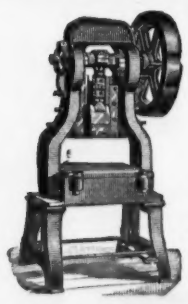

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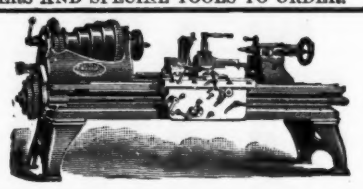

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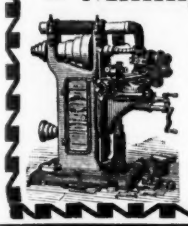

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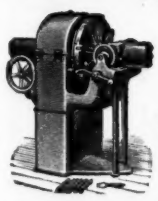

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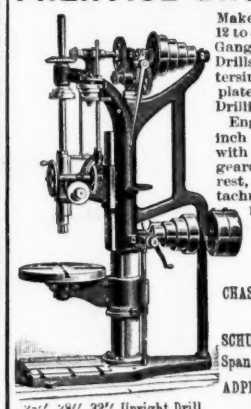

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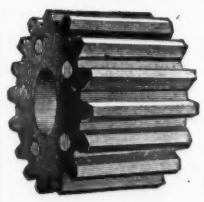

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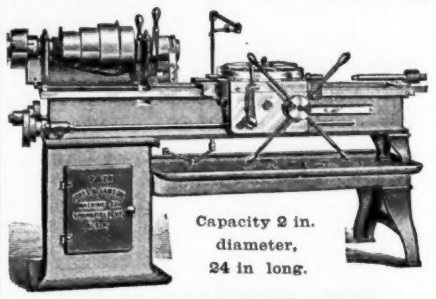

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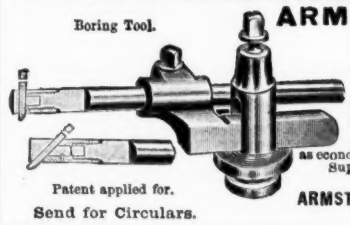

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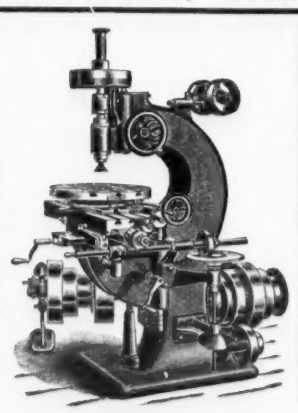

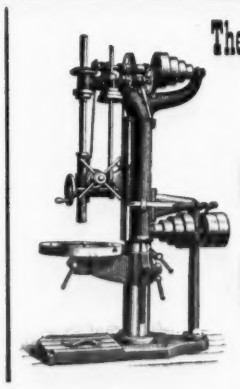

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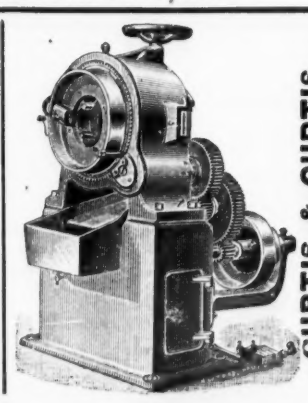

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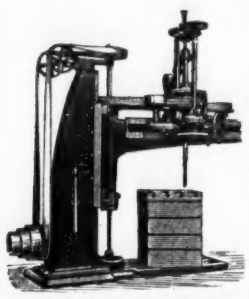

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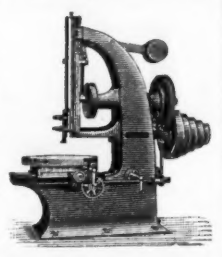

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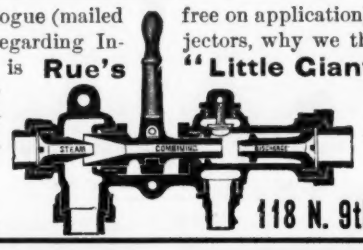

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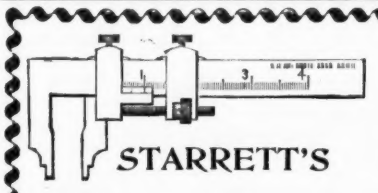

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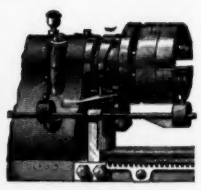

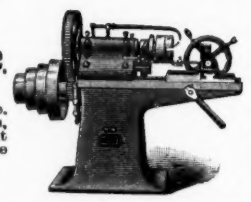

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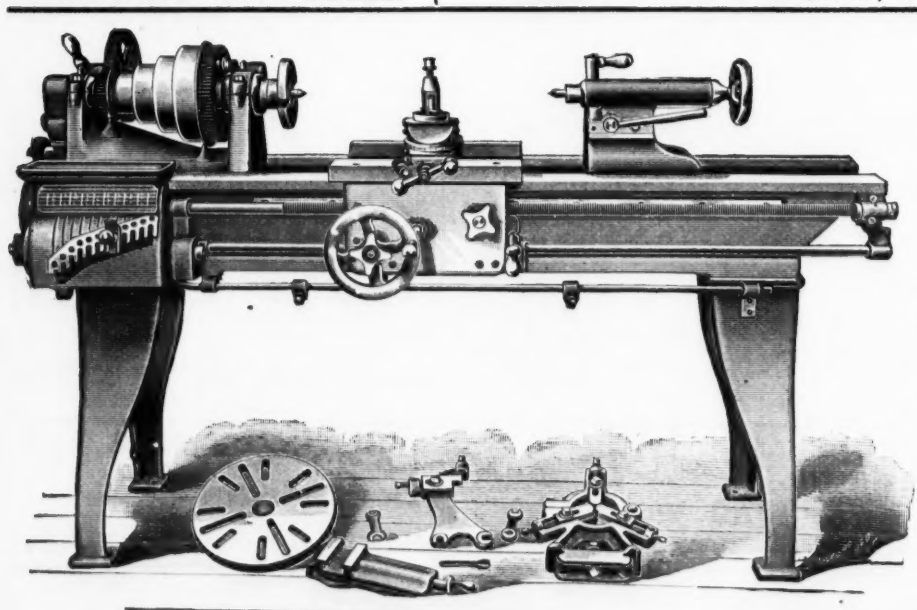

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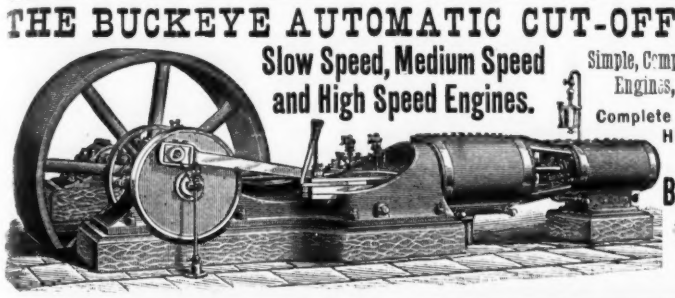

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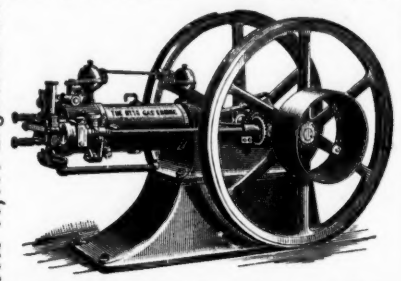

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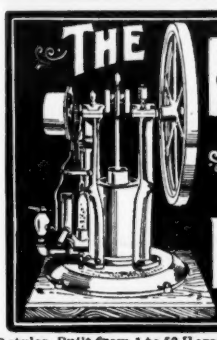

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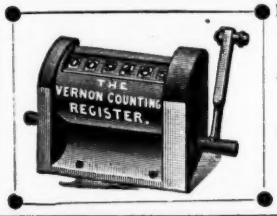


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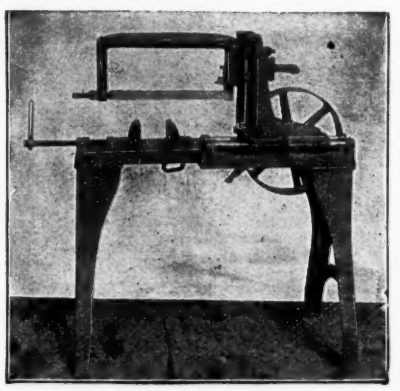

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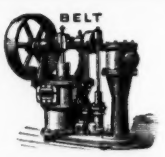


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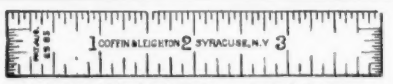


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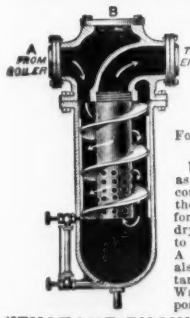


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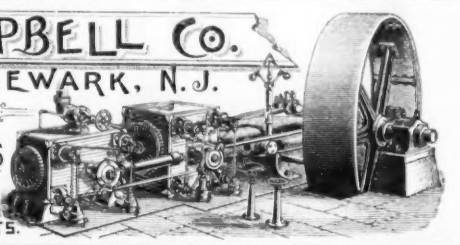

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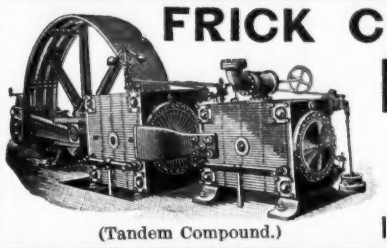

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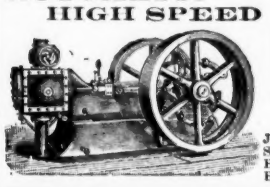

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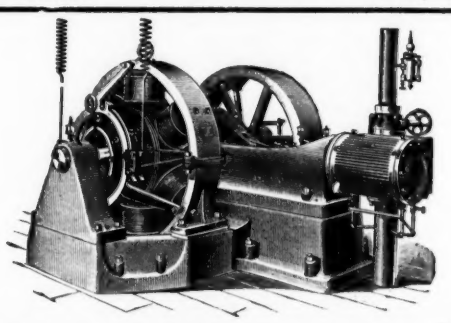

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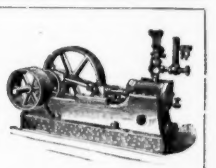

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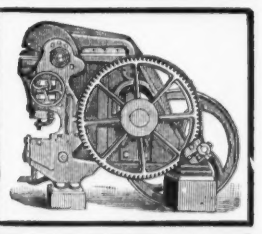

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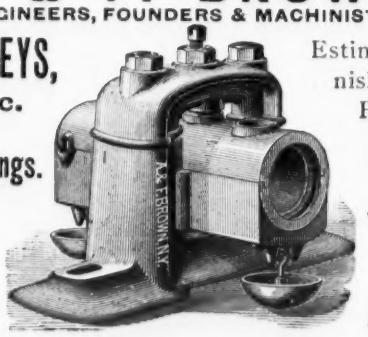


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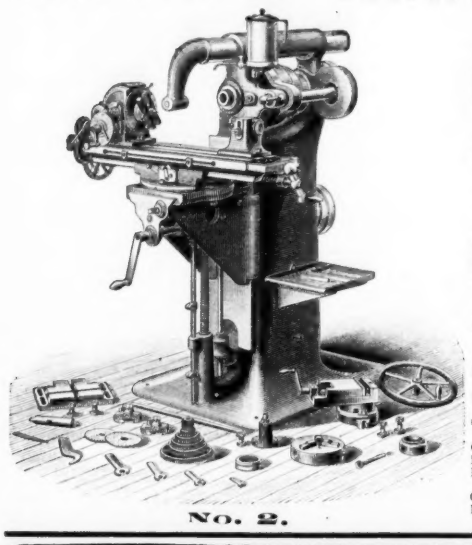

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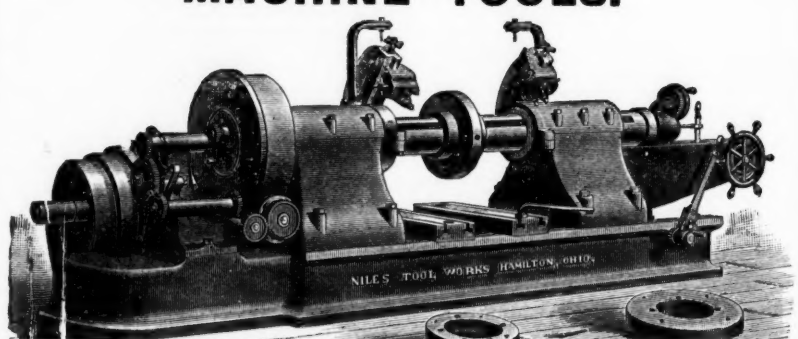


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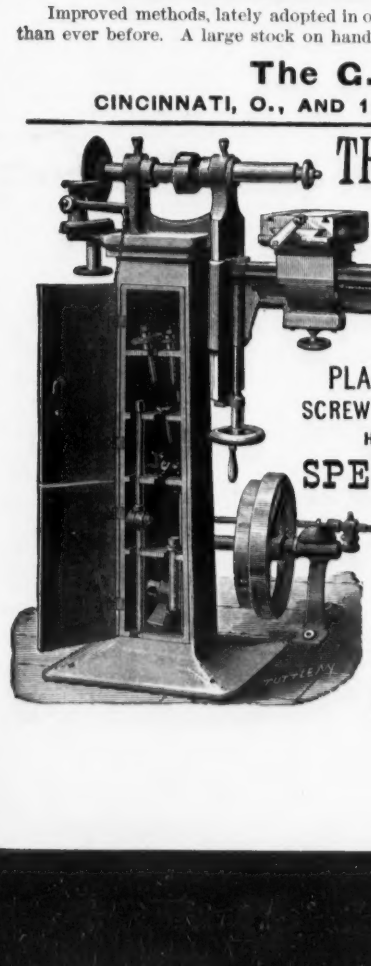

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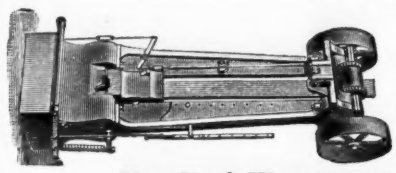

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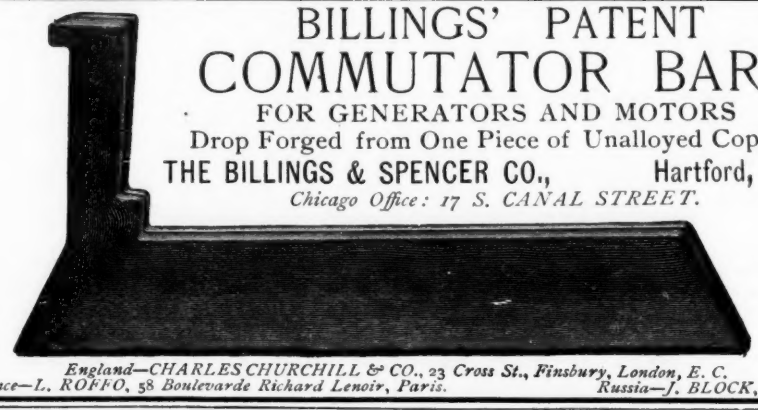

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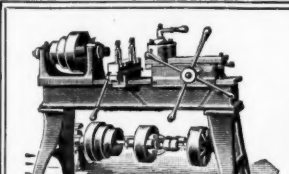

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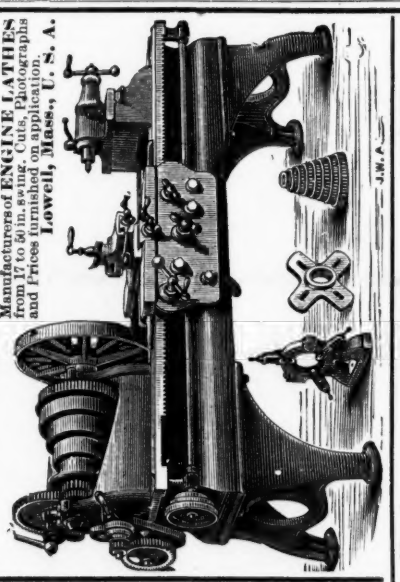

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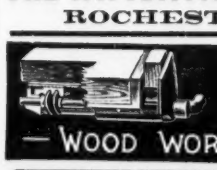


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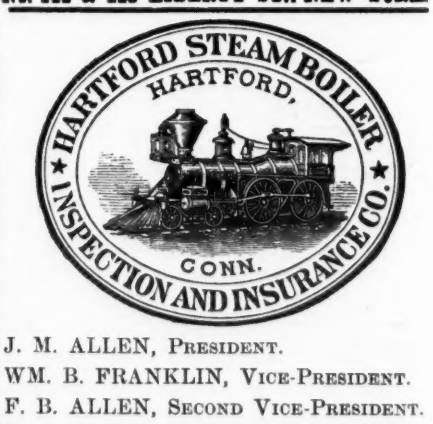


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